Eng Lib

GENERAL LIBRARY,
UNIV. OF MICH.
SEP 18 1911

SCIENTIFIC AMERICAN SUPPLEMENT, No. 1863

Entered at the Post Office of New York, N. Y., as Second Class Matter.

Copyright, 1910, by Munn & Co., Inc.

Published weekly by Munn & Co., Inc., at 361 Broadway, New York.

Charles Allen Munn, President, 361 Broadway, New York.
Frederick Converse Beach, Sec'y and Treas., 361 Broadway, New York.

Scientific American, established 1845.
Scientific American Supplement, Vol. LXXII., No. 1863.

NEW YORK, SEPTEMBER 16, 1911.

Scientific American Supplement $5 a year.
Scientific American and Supplement, $7, a year.

A THOUSAND DOLLARS AN HOUR GOING UP IN SMOKE [See Page 178]

A Great Oil Well On Fire.

Heroic Measures Adopted to Extinguish the Blaze

AFTER burning uncontrolled for twenty-five days and defying all efforts to extinguish it by usual means, a monster oil gusher in northwestern Louisiana was recently conquered by a daring and ingenious method, involving the construction of a tunnel over 200 feet long and the making of a connection with the well pipe, or casing, underground. One life was lost and three men were seriously injured in the explosion which occurred, presumably from the explosion of gas, when the well caught fire, and hundreds of thousands of barrels of high-grade crude petroleum were consumed while the flames raged. The work of subduing the fire was accomplished without accident or injury to any of the numerous men engaged in it, but the terrific heat from the burning oil severely tested their powers of endurance.

The well is the property of the Producers Oil Company of Houston, Texas, and is located on the Harrell farm, near the town of Vivian, in Caddo Parish, La., thirty miles north of Shreveport on the line of the Kansas City Southern Railway. It was completed with a rotary drill at a depth of about 2,300 feet and on the morning of May 12th was 'bailed in"—the "bailing" process consisting of running a section of pipe to the bottom of the hole to agitate the fluid and start it flowing. The oil came with great force through the 6-inch casing at a rate then estimated at 1,000 barrels per hour, and was accompanied by a heavy flow of highly volatile gas. After the well had been permitted to gush for a short time in order to clean itself out, the agate valve was partly closed, restraining the flow of oil and gas. While a workman was in the act of turning the gate valve handle for the purpose of further shutting off the flow, a terrific explosion occurred. It was as if a bomb had burst in the air. The only explanation appears to be that the gas, being as heavy as the air and remaining near the ground, floated away some distance and was ignited by a cigarette smoker, or in some other manner. In an instant the stream of oil from the well was on fire. The clothes of the four men working in and near the derrick floor were saturated with oil and were meat for the flames. One man succumbed. The other three were more or less seriously burned.

W. B. Sharp, president of the Producers' Oil Company, arrived on the scene early and personally directed the fight on the fire, remaining on the ground night and day for three weeks. It was he who devised and carried to a successful consummation the plan by which the flames were conquered and the well gotten under control.

Steam, which has been used in many instances to smother oil well fires, was first tried. The combined capacity of thirty-six 40-horse-power oil field boilers was concentrated through four 4-inch lines on the burning well, but without perceptible effect. Several dozen joints of drill-pipe which had been standing in the derrick when the well caught fire, fell when the derrick was consumed, covering the gate valve and causing the burning oil to be diverted in every direction. This complicated the matter, and in an effort to shoot away the fallen pipe and thus permit the oil to flow in a single stream, making it easier to cope with, or to prepare for the use of dynamite to lift the flame, a cannon was brought into use. Several shots were fired, but without the desired result. It was evident that the fire could not be overcome by dealing with it on the surface, and a decision was arrived at without further delay to tunnel into the well and cut off the flow of oil underground. This plan was carried out with complete success in fourteen days' time, and is described in detail below.

First, a tunnel was cut through the hard surface clay, starting at a point 208 feet from the well, and dipping at a slight angle. Pick and shovel were used for this work, that portion of the cut underground being 4 feet wide and 7 feet high. The top of the tunnel, at the well, was eleven feet below the surface. On account of the intense heat, the last 50 feet of the cut was extremely difficult; only two men could be worked at a time and they had to be relieved by fresh shifts every thirty minutes. Turpentine fumes, generated by the heat and escaping from the green pine timbers with which the tunnel was braced, burnt and blinded the workmen. Despite the various obstacles the tunnel was completed and a split clamp, or saddle, especially made for the purpose, was placed around the 10-inch surface casing and drawn oil-tight by means of stud-bolts, exposing in horizontal line toward the mouth of the tunnel an opening in the saddle, threaded for 6-inch pipe. One end of a section of pipe of this diameter, 208 feet long, was screwed into the saddle, the pipe extending to the mouth of

Tunneling Under the Burning Well to Divert the Flow.

A DELICATE PROBLEM IN ENGINEERING

the tunnel. The outer end of this pipe was equipped with a stuffing box, or packing gland. Inside this 6-inch pipe were placed 210 feet of 4-inch pipe, carrying an acorn cutting tool, with a 3-inch radius on its inner end. A sprocket wheel was fixed on the outer end of the 4-inch pipe, outside the 6-inch pipe, and this sprocket wheel was connected by an endless chain with the pinion on a drilling engine. By this means the 4-inch pipe was rotated, and the acorn cutting tool was made to cut first through the 10-inch surface casing, then the 8-inch casing and finally through and into the 6-inch casing which carried the oil flow. The acorn tool was so shaped that it cut off almost the entire flow of oil through the 5-inch casing to the surface, and it contained a hole through which the flow was diverted out through the 4-inch drill pipe. Measurement of the oil escaping through this 4-inch pipe showed 9,000 barrels in 24 hours, while almost 1,500 barrels escaped in the same time through the 6-inch pipe extending to the tunnel's mouth; but much oil got by the acorn cutting tool, to feed the flames too strongly for the steam lines to snuff out.

The next move was to connect two 18 x 5 x 18-inch line pumps with the outer end of the 4-inch pipe, and by this means water was pumped into the well at a pressure of 1,200 pounds to the square inch, against the natural pressure of the oil and gas in the well, which was 900 pounds to the square inch. The water escaped through the 6-inch well casing to the top and very nearly extinguished the fire. For the purpose of entirely cutting off the flow of fluid past the acorn tool and through the 6-inch well casing to the surface, small balls of asbestos wicking, about an inch in diameter, were placed in a trap and pumped into the well through the 4-inch pipe. The opening in the acorn tool as it stood in the 6-inch casing was toward the bottom of the well. The asbestos balls choked up the small balls of asbestos wicking, about an inch in diam- past the acorn tool to the top and effectually cut off the flow. In 18 minutes the fire had died out. Muddy water was pumped into the 6-inch casing through the 4-inch pipe and the well was thus temporarily "killed." The acorn tool was removed, new connections were placed on the well and it was again "bailed in." A test of its capacity showed a flow of 2,000 barrels an hour—or at the rate of 40,000 barrels a day. This entitles it to rank as the largest producer of high-grade petroleum in the history of the oil industry. The oil from the well is almost up to Pennsylvania grade, testing 45 degrees Beaumé. Because of lack of pipe line facilities to handle the output, the well is permitted to flow only 10,000 barrels a day. An 8-inch pipe line is now being laid by the Texas Company from its tank farm at Ardia on the Red River, five miles below Shreveport, to the big well, for the especial purpose of running the oil. The Texas Company has an 8-inch trunk pipe line in operation from Ardis to its refinery at Port Arthur, Texas.

We are indebted to the Producers' Oil Company for this description and the illustrations of the recent occurrences at the Harrell oil well.

Electrical Resistance of Pure Metal at Very Low Temperatures.

For several years Prof. H. Kamerlingh Onnes, of Holland, has carried out exceedingly interesting experiments on the enormous decrease of electrical resistivity which pure metals undergo at very low temperatures. He has now perfected his experimental facilities for the use of liquid helium (which by the way was found to be an excellent insulator) and the results of his determinations of the resistivity of pure gold and mercury at liquid helium temperatures are given in abstract in the London *Electrician*. The author's recent experiments with gold have greatly strengthened his former conclusion that the resistance of pure gold vanishes at helium temperatures. Even more interesting are the experiments with mercury. The measurements were made with the differential galvanometer by the method of overlapping shunts (Kohlrausch) and also by the method of the measurement of current strength and of potential difference. The value of the mercury resistance used was 172.7 ohms in the liquid condition at 0 deg. C.; extrapolation from the melting point to 0 deg. C. by means of the temperature coefficient of solid mercury gives a resistance corresponding to this of 39.7 ohms in the solid state. At 43 deg. K. this had sunk to 0.084 ohm. At 3 deg. K. the resistance was found to have fallen below 3×10^{-6} ohm. As the temperature sank further to 1.5 deg. K., this value remained the upper limit of the resistance. The next step was to look for the point at which the resistance first becomes measurable as the temperature is raised. The temperature of this point was found to be slightly more than 4.2 deg. K.

The Great Star Map.—III*

Counting the Stars

Continued from Supplement No. 1862, page 163

By Prof. H. H. Turner

OUR rather long digression has not taken us so far from the topic immediately concerning us as might at first appear. Without some explanation it would not have been easy to realize the importance of mere counts of the number of star images of a certain size. They might have been regarded as of academic interest merely, whereas we now see that they furnish evidence on two fundamental questions: firstly, is our Sun merely an individual star or is it associated with other stars in a family or cluster? secondly, is there an extremely tenuous "fog" of matter prevading the spaces between the stars and if so what is its density? We shall find that the first of these questions is presented again in another connection when we come to the movements of the stars; but the existence of some sort of solar cluster is established by simple numeration combined with measures of brightness.

How are we to measure the brightness of stars photographically? In approaching any measurement of differences we must first satisfy ourselves that we can recognize equality. Let us define as of equal photographic magnitude two stars which impress the same plate equally in the same time and we need go no further to encounter trouble. Suppose we pick out two stars by this rule, will they remain equal if we substitute a different plate? The answer is in the negative: for if one of the stars be a red star and the first plate be isochromatic, we shall find the image of the red star much fainter on substituting an ordinary plate. If our photographic magnitudes are to mean anything, we must keep to the same kind of plate. Strict uniformity in this respect has not been possible: the sensitizing of films is an art rather than a science and when a firm of plate makers changes its artist, the plates undoubtedly change in character. But it is hoped that the variations in character of plate throughout the work have not been serious enough to introduce large errors, though this is a point on which our information is not very complete. Moreover this is not the only trouble. Two stars showing similar photographic images on the same plate may be made to give dissimilar images by slightly turning the telescope so that the images fall on different points of the plate; or by refocussing the telescope. The apparent photographic magnitude may thus depend upon the distance of the star from the plate center and upon the particular focus selected for the plate. The difference is so slight that it might escape detection by the direct process of comparing images: but it can be made unmistakably manifest in a very simple way. It has been already mentioned that the plates of the Star Map are ruled with a series of cross lines, called a reseau, dividing up the plate into equal squares. Let us count the number of star images in each of these squares for a large number of plates and add together all the counts for each particular square; then if stars photograph equally well all over the plate, the total numbers for each particular square ought to tend to equality: the stars are scattered sufficiently at random for this purpose. Now it is found that on the plates of the Star Map the numbers do *not* tend to equality: at the edges of the plate, the totals per square are considerably less than nearer the center—the inequality may be as great as 1 to 2. The increase, however, is not maintained up to the center; it reaches a maximum and then falls off again, unless the plate happen to be focussed in such a position that the center is most favored. The phenomenon depends, in fact, on the focussing of the plate: if it be focussed for the center, then the total per square will be greatest at the center and will fall off steadily toward the edges; but it is customary to push the plate a little farther in than this, so that the region of best focus is a ring intermediate between the center and the edges and on this ring the total-per-square is greatest, falling off both towards the center and towards the edges. Photographers accustomed to ordinary cameras will read these words with some surprise for they may not have noticed in their experience any corresponding phenomenon; but the reason of this is simply that they use a different kind of lens—a "doublet" made up of two lenses separated by an interval, and with this combination the trouble does not occur. In sketching the early history of the Star Map it was pointed out that the selection of a lens was one of the important decisions taken by the Conference of 1887, and that it was decided not to use a doublet lens—chiefly because of the expense. But in other connections stars have been photographed with doublet lenses and it has then been found that the inequality of distribution of images disappears or is very considerably reduced. With the lenses used for the Star Map, however, the inequality is marked. By noticing where the total-per-square is a maximum we can ascertain to a nicety how the plate has been focussed and whether the focussing has been changed from one time to another. The position of the maximum changes slightly with the season of the year, doubtless owing to the expansion and contraction of the lens and the tube with variations of temperature. We can even tell whether the plate is tilted slightly to one side, for then the position of maximum will be farther from the center on one side than on the opposite.

Hence it will be seen that the determination of the photographic magnitudes of the stars is beset with difficulties from the outset. We must take into account the kind of plate used and the position of the star on the plate if we are to get comparable and accurate results. Nevertheless much information can be obtained by very simple means if these essentials are attended to. Suppose we take two plates from the same batch and expose them for the same time on the same night, one to a region in the Milky Way and the other to a region far from it: and that we then count the total number of stars upon each. There will be many more on the former and we can find definitely what the ratio of the two numbers is. Repeating the comparison with a longer exposure (still the same for both regions), we shall get another ratio. From the study of these different ratios for different lengths of exposure, we get information bearing directly upon the two great questions we have been studying—the existence of a solar cluster and of fog in space: for we must ascertain whether the Milky Way is in any way related to these possibilities. Hence it will be understood why counting all the stars on a plate, trivial as it might appear at first sight, has been an important operation in connection with the Star Map. It is usually done with a "billiard-marker." Those who play billiards have various devices for marking the score, one of which is a small apparatus, held in the hand, provided with two or four little springs. On pressing one of these springs one of the numbers shown on the face of the apparatus changes and by a series of clicks the score is registered as required. Now one of the astronomers who was taking a share in the chart had "misspent his youth" and accordingly knew of this apparatus and saw that it would be useful for counting star photographs; for the plate can be passed in review under a microscope with one hand, while with the other hand a click can be made, without removing the eye from the microscope, whenever a star is seen. The success of the performance has been sufficient to cause "billiard-markers" to be exported to distant astronomical observatories, where there is, as a matter of fact, no billiard-table.

But how comes it that different exposures are given in the actual course of the work on the Star Map? Is not uniformity one of the essential features of the scheme? It was certainly the original idea that a particular length of exposure should be selected and adhered to throughout: fifteen minutes found most favor. It was considered, in the light of the experience available, that fifteen minutes would give stars as faint as the 14th magnitude, and was not so inconveniently long as to be a tax on the observer. After this had been practically settled it was remarked that the bright stars would, with so long an exposure, form very large images, the center of which could not be accurately determined. Now it is important to measure these bright stars accurately, for we already know their positions in the sky with some precision, and they are therefore useful reference marks for the others. Hence it was decided to take another series of plates with a shorter exposure (ultimately fixed at six minutes), on which the images would not be so large. This bifurcation of the enterprise was subsequently developed in both prongs. To the shorter exposure, two others shorter still, of 3 minutes and 20 seconds, were afterwards added, for good reasons which we need not stop to notice: and the longer exposure of 15 minutes was extended to 20 minutes, then to 30 minutes, then to 40 minutes, and ultimately to one hour, subdivided into three separate exposures each of 20 minutes. We need not follow the reasons in detail, it is sufficient to remark that for the originally projected uniform exposure of 15 minutes a series has been substituted, for reasons more or less good, of four or five exposures ranging from 20 seconds to 40 minutes. The ratio of 120 to 1 between the longest and shortest corresponds roughly to 7 stellar magnitudes and hence we have material for studying the variation of total stars per plate over a considerable range.

The particular proposal to give three separate exposures of 20 minutes each has had an unexpected result of an interesting kind. The three exposures are arranged in the form of a little triangle, so that each star is represented by three little dots in this figure. Now these long exposure plates are not to be measured but are intended for reproduction as charts. They represent the most expensive part of the project, each of the eighteen shares costing some £10,000 in all. At Oxford and at some of the other less wealthy observatories it has not been possible to undertake this expensive part of the work, but the French are particularly interested in it, as a consequence of earlier national projects of the same kind; the French Government has most generously undertaken the reproduction of the "Charts" in the Oxford zone and in some others. These charts are being very beautifully and carefully reproduced in Paris by heliogravure. As each chart is printed it is patiently examined for possible defects, to see for instance whether any of the images on the original plate are missing or whether any accidental blots could be mistaken for stars. One test applied by M. Jules Baillaud, who has special charge of this work, is a comparison of the three separate images of each star to see that they resemble one another; if they do not there is usually some defect in the reproduction calling for correction. But what was his surprise one day to find a distinct difference in the images of a particular star which was not a fault of reproduction but was apparent in the original plate itself! The conclusion was forced upon him that the star had varied in brightness between the exposures. The interval is usually so short that such an occurrence would be startling, but in this particular case there had been, owing to an accident, a longer interval than usual. After two exposures had been successfully given, clouds had come up and it was impossible to give the third on that night. But in these days of "dry plates" such an occurrence does not mean the loss of the work already done; it was only necessary to close up the plate securely until the next fine night when the telescope was again pointed in precisely the right position and the third exposure given. But meantime the star had changed in brightness a little, and so M. Baillaud's careful scrutiny enabled him to discover that it was variable—a success which he afterwards repeated in another instance. Indeed the accident was suggestive; just as an accidental effect at rehearsal is often deliberately adopted subsequently in the play itself, so it was made clear by the unavoidable separation of the exposures in question that there would be a distinct advantage in separating them deliberately. M. Baillaud made this suggestion at the recent meeting of the Permanent Committee and the wisdom of it was at once recognized.

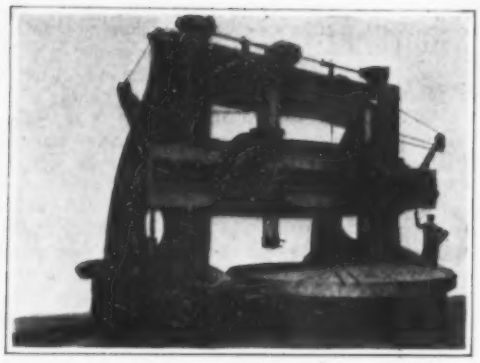
The detection of variable stars, however, is not a regular part of the work on the Map. These objects are few and exceptional; we are concerned chiefly with the many and the average. The many are counted by thousands and millions, thousands of stars on a single plate and millions on the whole collection of plates. Perhaps a few definite figures may be given here: not too many of them, for they are apt to be tiresome; but one or two representative figures will give a crisper idea of the magnitude of the work.

There are eighteen observatories concerned; the shares of each is about 1,200 plates, taken twice over with short and long exposures. Fixing our attention on the short exposures, there are on the average 400 to 500 stars on each, the places of which are to be measured and recorded. But this average is struck from numbers which diverge widely; on some plates there may be 5,000, on others less than 100, the rich plates being of regions in the Milky Way and the poor ones of regions far from it. Each observatory has thus to measure about half a million star images and as the number of figures required to record each measure may be several dozen, it is easily seen that many millions of figures are used by each observatory. These measures took a staff of four or five people at Oxford some ten years or so to complete; and the printing of them another four years. The checking of so many figures in the proof sheets is no trivial matter, since it is important to avoid mistakes—astronomers know the trouble which may be caused by a wrong figure, once it gets into print.

In dealing with so many figures it is important to devise tests of their accuracy. In mathematical calculations, a whole series of operations can sometimes be tested from a single result; if that is correct, there cannot be a mistake in any of the operations, at any rate not one mistake alone. Just so in money accounts, if the totals check one another, it is usually fair to assume that the individual items are correct. In the case of the Star Map no such economical tests are possible. We must be content to check each star by itself and for this purpose two measures are made of it under different conditions. After all the stars on a plate have been measured, the plate is taken out of the measuring apparatus, turned round through 180 degrees and remeasured. In this way nearly all the unintentional slips are detected.

(To be Continued.)

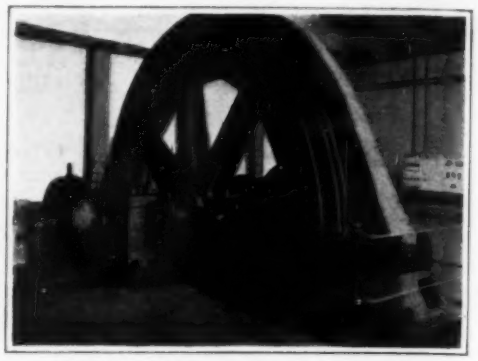
* Reprinted from *Science Progress*.



Planing Machine of the German Niles Machine Works.

Machine Beauty

Aesthetic Evolution in Engineering Structures



Triphase Alternator at Aix-la-Chapelle.

FROM time to time, when a great reservoir is built in the mountains, or a waterfall is turned to technical uses, or a factory is erected in a picturesque region, complaints are made of the destructive and purely utilitarian activity of the engineer. The destruction of the Falls of Niagara, the submergence of the island of Philæ, the continual invasions of the romantic scenery of the Rhine, are brought forward as evidence of this pernicious activity. It must be admitted that in many cases the constructors of new technical works might well have shown more consideration than they have shown to the monuments of nature and civilization. On the other side, however, it must be conceded that the increase in the wealth and fertility of a country, apart from its merely economical value, ultimately elevates the plane of life of the population and thus becomes indirectly a source of new beauty. The engineer of to-day can adduce even stronger evidence in his favor. His machines and his structures are themselves works of beauty of a new kind from which æsthetic consideration should no longer be withheld. To the charm of natural scenery and works of art the beauty of technical creations is being added more and more rapidly, and the artists are preparing to learn from this beauty and to co-operate in its enhancement. There is a great difference between the beauty of the masterpieces of art and that of machines and engineering works in general. Technical beauty may be designated as organic and closely related to life. A machine differs from a statue, not only in purpose and material, but also in the rhythmic interaction of independent forces, a quasi-organic process, which takes place in it. A quite similar distinction may be made between modern iron bridges, railway stations and similar structures and the old masonry structures. The individuality of the modern steel building is not less than that of the old church or palace, as has been asserted, but is greater. In it a sharp division is made between the merely supporting parts which are represented by the steel skeleton, and the foundation and envelope of stone, wood, glass and concrete, and to this functional distinction is added the elimination of the sharp contrast between horizontal and vertical parts, together with greater breadth and brightness, so that an organic interaction of forces appears to pervade the whole structure. The organic life of machines and buildings is more complete in proportion to their adaptation to their purposes, and the degree with which this adaptation is indicated by their external form determines the grade of beauty of the structures. A higher technical perfection means a higher beauty. This is a characteristic of technical as of other beauty. This explains why it has taken so long for engineering works to assume beautiful forms and why this development is yet in its infancy.

Organisms of this new kind are found in modern machinery of all classes, according to Franz Mannheimer, of whose article in *Reclams Universum* this paper is an abstract. The steam engine was the first to show the new tendency, as it forms the foundation of modern industrial life. If we compare two steam engines differing in age by a century, an engine of Watt and a new Sulzer compound engine, they appear at first glance to be machines of totally different classes. The engine of Watt's, even in the most improved form that he gave it, bears a strong resemblance to the old spinning wheel. The walking beam, an inheritance from the non-condensing pumping engine, divides the machine into two parts which work clumsily together. In the modern engine, on the contrary, three large cylinders lie close together, almost imbedded in the ground, the fly wheel is broader and more massive; but, above all, the connection between the piston and the shaft exhibits an obvious adaptation to its purpose and a true organic character. The connecting rod extends like an arm from the piston rod to the crank, which it grasps as if with a clenched hand. It seems like the arm of a giant, whose body, filled with fire and steam, is buried in the ground with only the mighty shoulders protruding. In the locomotive, on the other hand, the body, or boiler, is the most conspicuous part. Here also a long course of development was required to produce the light and elegant forms of the newest express locomotives.

In the steam turbine, in which the steam, entering through small channels, sets a ring of blades in rotation, the completely closed cylindrical housing with its massive supports and perfect immobility conveys the suggestion of the great forces which work ceaselessly within it, like an active brain behind an unruffled forehead. The explosion motors, in which the harmonic combination of the valves and pipes for the explosive mixture with the cylinder and fly wheel is difficult and has not always been successfully attained (in the Diesel motor, for example), have yet contributed much to technical beauty by making possible the development of automobiles and aeroplanes. Like the locomotive, the automobile in its more recent development has divested itself of all heaviness and clumsiness. The seats are placed low, the tapering front gives the car the appearance of an arrow or boat and in itself suggests rapid forward motion. The peculiar beauty associated with the dirigible balloon and especially with the aeroplane, almost from the beginning, is apparent to every observer.

In electrical industry the dynamo or generator presents one of the most majestic technical creations in existence, and the great dimensions which it has assumed in modern power stations add to its imposing character. In these great, swiftly revolving circles of magnets and coils the silent and inexhaustible electrical energies appear to be incorporated. The symmetry of the machine and its massive housing and appendages also produce a pleasing effect, as in the case of the turbine. Here, however, the development of beauty goes further. Like steam in the locomotive and explosive energy in the automobile, electricity has created a type of technical elegance in the electric car. In our houses, the electric current operates fans, heaters and clocks, and here and elsewhere it furnishes light. For these purposes it demands in some cases entirely new forms of heaters, lamps and ventilators, in other cases it leads to the transformation of the older forms. Here, where the association with the art industries is especially close, the first gratifying and tangible æsthetic results were achieved.

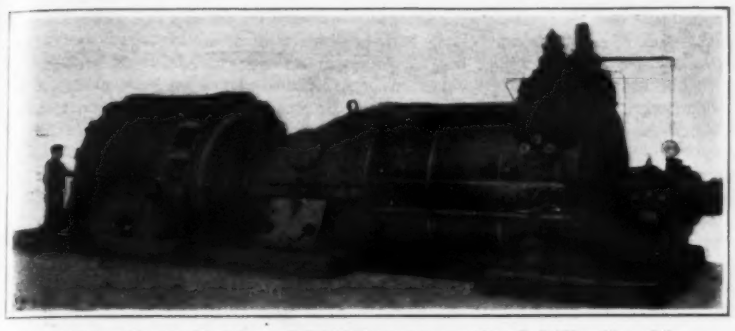
Behind the electric generators and prime movers of all classes stands the host of machines and machine tools with their infinite diversity of form. They include transporting machines, such as the crane, the latest development of the simple lever, which plunges its powerful hands into the ship's hold and seizes its cargo, and machines for the working and transformation of materials of all kinds. The observing eye will find beauty in the steam plows and sowing machines which traverse the fields, the stone crusher with its mighty jaws, the swiftly moving shuttle of the loom, the various machines which roll, press, twist and cut bars of steel for the making of new machines for other purposes, and even in the great cannons and machine guns, rifles, and other modern engines of destruction. Metallurgical establishments have often furnished subjects to artists, who are attracted, however, only by the active technical life there shown, not by the machines themselves. Here, on the contrary, we wish to lay special stress upon the individual machines, the construction of which is often not very clearly apparent, but which, in their operations of boring, planing, turning, etc., appear like embodiments of an unerring and omniscient spirit of work.

More striking than these machines, which are usually hidden in factories, are the modern technical structures, formed of iron ribs alone or combined with glass and stone, the railway bridges, elevated railways, stations, factories and exhibition halls. But although these buildings carry in themselves a possibility of an organic existence, they showed little of the organic character at the beginning. Just as many old steam engines were adorned with Doric columns of cast iron, the older railway stations were ornamented like Gothic churches, and factories were erected in the style of castles. Even the buildings which on their erection were deservedly hailed as the first indications of the iron style are no longer entirely satisfactory. Paxton's Crystal Palace for the London Exposition of 1851, which was then regarded as a

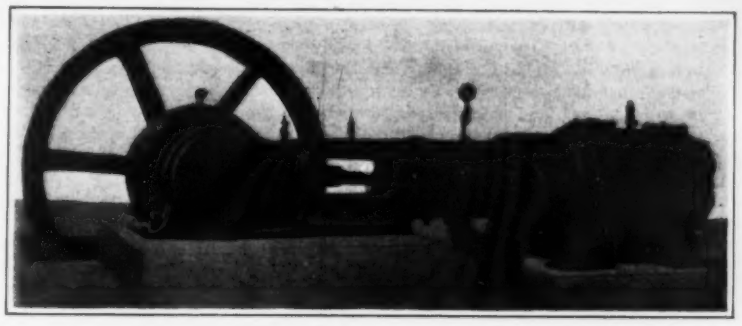
Hydraulic Forge Press, at the Borsig Iron Works in Tegel.

Interior of Turbine Hall of Allgemeine Elektrizitäts Gesellschaft, Berlin.

WHERE UTILITY AND BEAUTY HAVE MET TOGETHER.



Sulzer Steam Turbine of 9,000-Horse-power, Coupled Directly with Low Phase Alternator.



Directly Coupled Air Compressor and Steam Engine (Borsig Works).

masterpiece, too plainly betrays its lineal descent from the greenhouse, which was here expanded into a church-like form with nave and transept, while the narrow and closely placed pillars surmounted by small round arches plainly show how little the architectural style suited to the nature of iron was then understood. Fifteen years later Barlow constructed in London in the St. Pancras Station, the first hall spanned by wide iron arches, which became the prototype for many other railway stations, including the Anhalt Station in Berlin. In 1889 arose the Eiffel Tower, a structure of entirely new form, and the Machinery Hall of the Paris Exposition whose great width of 374 feet was spanned by inclined iron arches. In both of these structures the undivided spider web-like lattice work should not be lost sight of in our admiration for the general effect. A sort of museum architecture impairs the exterior beauty of most railway stations (the Antwerp station is an exception), and the same is true of the tops of the pillars of many iron bridges. The style of the Crystal Palace reappears in the lattice work of the old Weichsel bridge at Dirschau, while the new bridge represents the bolder iron style of the present day. The most imposing structure of this character is still probably the bridge over the Firth of Forth at Edinburgh, which suggests a mighty dragon cowering over the narrow strait. In this structure everything speaks of iron and of purpose, and therefore the general effect, at least, is beautiful. In the newer Rhine bridges, on the contrary, especially in the Cologne bridge, the addition of castle turrets has impaired the beauty of the iron parts, without improving the effect of the whole bridge.

The defects that still adhere to the technical monumental style can be removed. For this purpose a better understanding than now exists between technical engineers and architects is essential. Artistic perfection can be obtained only when the architect places himself on the ground from which the technical beauty of engineering works has arisen. The German General Electric Company adopted this idea when it appointed Peter Behrens as artistic director of all of its undertakings. In this action the company gives recognition to the fact that technical development is now sufficiently advanced to profit from the co-operation of an artist. The style which Behrens has exhibited in his architectural and artist-artisan work is based entirely on the sober logic of number, mass and space, and is therefore eminently well suited for this purpose. The first result of this co-operation was not a monumental building, but such objects as arc lamps, electric fans, etc. The ugly sheet iron envelope and the shapeless glass globe of the arc lamp, which all kinds of inappropriate ornaments failed to beautify, gave place to more pleasing forms. Behrens next proceeded to the construction of a turbine hall for the Berlin branch of the company, and here the peculiar beauty of the iron style was effectively developed by this able artist. This building is devoted entirely to turbines and is separated from the other buildings. We are accustomed to picture a factory as an uninteresting structure of red brick and iron beams, with narrow windows and bare walls. The new turbine hall is constructed entirely of iron, glass and concrete. The side windows extend nearly from the eaves to the ground, and are separated by iron pillars resting on concrete bases. The corners of the building are imbedded in heavy masses of concrete, and a concrete gable rises above the great front window. The harmony of coloring, exhibited by the gray of the concrete, the dark green of the glass and the dull pale green with which the iron parts are painted, adds to the effect. The interior of the building, with its wide main hall and narrower lateral addition, resembles an iron church. Especially surprising is the brightness of the illumination which enters from the sides and particularly from the roof. The harmony of proportion between the roof and its supports is also noticeable. In such a building, work appears to be ennobled and freed of its grime and tedium.

This, indeed, is the most important consideration. If, as we have a right to expect, this combination of artistic and technical ability shall be further developed, producing spacious and brightly lighted factories, and technically beautiful machines in technically beautiful buildings, factory life will lose the character of laborious penal servitude. It is true that factories are not festal halls, and machines are not statues, and furthermore, that the æsthetic factors of social improvement are less important than the economical factors. Nevertheless, the technical beauty of machines and workrooms may tell the worker that the work of his hands is no mean task, inspire them with love for his work and relieve him to some extent of the dull hopeless feeling of slavery. To the general public this beauty can convey the message that the technical achievements, which we all gladly utilize without fully understanding them, are something more than aids to the convenience of life. Technical industry is a field of culture, which is broad, and filled with hidden beauty, and which eagerly awaits the hands which will bring forth this beauty to full fruition.

Practical Aspects of Printing Telegraphy—VIII*

An Inventor on the Difficulties to be Encountered and the Way to Overcome Them

By Donald Murray, M.A.

Concluded from Supplement No. 1862, page 168

One argument used against page-printing by those who have been trained up in the use of tape printers like the Hughes and Baudot, is that as every correction and inquiry involves the use of a message form, there is great waste of message forms. Actual observation during the practical trial by the British Post Office showed that the loss from this source did not exceed 5 per cent of the message forms used, and even this small loss could be halved by a little care and foresight. Also the writer has designed an arrangement by which inquiries and corrections (R Q's) can be obtained directly printed on a tape, thereby avoiding any waste of message forms, and also avoiding delay. Mention has already been made of the manner in which provision is made at the sending station for direct transmission of R Q's, even in the middle of the transmission of a message, by perforated tape. At the receiving station it is obvious that the R Q must not be printed on the message, the transmission of which has for the moment been interrupted. To get over this difficulty, a small reel of paper tape is provided on the typewriter carriage, and a strip of the tape is stretched along the platen just clear of the printing point. It remains out of the way during the printing of a message. If the operator at the distant station has an R Q to transmit direct, after he has thrown over the necessary switches, as already described, he transmits a special signal (secondary A) which causes the tape on the printer carriage to jump up into the printing position. The printing of the R Q then proceeds direct on the tape, the receiving operator pulling out a fresh portion of tape when necessary. The message form underneath is protected by the tape which receives the printing. When the R Q is finished the receiving operator pulls down the tape device out of the way, and the printing of the interrupted message in page form can be continued. This arrangement introduces some extra complications, and it is not necessary except in cases where it is desired to save every possible second of time. It is hardly worth while for the sake of saving a few message forms, especially when many R Q's of a brief character and unintelligible to the outside public can be printed at the foot of the page-printed messages, and then struck out with a pencil by the receiving operator.

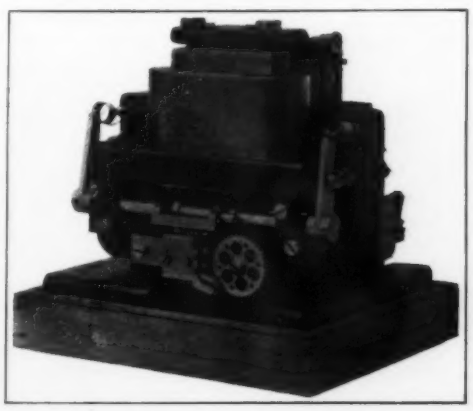


Fig. 16.—Murray Multiplex Receiving Perforator.

An important point to be noted about this multiplex printer is that the five setting magnets have very little work to do. They have merely to perform a slight releasing operation. Consequently they can be successfully operated by a very small contact on the distributor. The value of this lies in cases where a considerable number of transmissions (4 to 6) may be required. Under such conditions the contacts on the distributors are necessarily very small.

RECEIVING PERFORATOR.

With a multiplex printing telegraph system it is a comparatively easy matter to give three towns, A, B, and C, independent and simultaneous communication with each other on one telegraph wire. That is to say, it is not only possible but easy to arrange for A and C to be in direct communication while B is in direct communication with A and with C. More complicated arrangements can be made for simultaneous intercommunication between a larger number of towns, but the increased complexity soon puts a commercial limit on this arrangement. In the case, for instance, of town A transmitting telegrams through town B to various towns C, D, E, F, etc., one message going to one town and another message to another, there would be great difficulty in arranging any system of direct communication on one wire. In such cases there is another solution, namely, recording the messages in town B in the form of perforated paper tape. The messages can then be sent on automatically to any other city desired, and without any great complexity of mechanism. There is no cou-

* Paper read before the Institute of Electrical Engineers.

tinuous chain of mechanism, the breaking of any one link of which will cause the whole arrangement to collapse.

In the Murray automatic system all the received messages are first recorded at a high speed as perforations in paper tape, and from this perforated tape the messages are afterwards printed automatically. In the Murray multiplex a different kind of receiving perforator is provided. This instrument is shown in Fig. 16. It is essentially a Murray keyboard perforator tilted up on end and with the keys omitted. In place of the keys there are five small magnets which do the work of the keys—that is to say, they control selectively five small steel rods, which determine the holes to be punched in the paper tape. These five magnets correspond exactly with the five setting magnets of the multiplex printer (see Fig. 8). Each of these five setting magnets of the receiving perforator are placed in series with the corresponding one of the five setting magnets of the printer. The punching magnet of the receiving perforator is operated by the same impulse as that operating the printing magnet (Fig. 8) of the printer. On the printer there is provided a switch to throw the receiving perforator into or out of action by means of a signal from the distant station. If the sending operator at the distant station A has a message which requires to be transmitted at station B. This puts the receiving perforator in signal which throws over the switch in the printer at station B. This puts the receiving perforator in action. The message is then recorded as perforations in tape by the receiving perforator at the same time as it is being printed in page form by the printer. At the end of every message the page signal, in addition to turning up a fresh telegraph form, automatically cuts out the receiving perforator. Consequently only messages requiring retransmission are perforated, and the sending operator has control over this operation at the distant station. As there is a printed message produced at the same time as the perforated tape a glance at the printed message will show whether it has been correctly received. If it has been received correctly, then it can be automatically retransmitted to its destination by means of the perforated tape. If the message has not been accurately received, it can be corrected and sent in the ordinary way by manual instead of automatic retransmission. That is to say, it can be perforated again correctly on a keyboard perforator. In this respect the receiving perforator and tape retransmission present a decided advantage over the methods of direct communication between several towns, because any breakdown of the receiving perforator leaves all the ordinary working mechanism intact, and transmission can proceed in the ordinary way. This multiplex receiving perforator offers two main advantages in addition to that just mentioned, namely, (1) the message is printed and also perforated simultaneously, (2) only messages requiring retransmission are perforated. The others are printed only.

PREPARATION OF MESSAGE FORMS.

It is obvious that in a page-printing telegraph printing direct from the received signals, it is necessary to have some positive and automatic method of throwing out the finished message and feeding up a new message form to the right printing point. This may be done in two ways: (1) By feeding from a pile of cut forms, or (2) by means of a continuous roll of message forms. During recent years a number of devices have been perfected for feeding in separate sheets of paper one after another automatically into printing machines. There are undeniable advantages in this cut form plan, but the cross motion of the typewriter carriage presents serious obstacles to its employment in printing telegraphs. There is also the consideration that occasionally a message form may fail to feed into the printer, and the corresponding message would not be recorded. This would entail delay and repetition, and in some cases confusion and possible loss of a message or delivery of a message twice over. The continuous roll feed is free from these objections, but it entails preparation of some kind beforehand. Some slit or perforation has to be made in the paper band at the top of each message form to ensure positive feeding in of the forms to the right printing point. The messages have also to be cut apart with a pair of scissors or by other means. The arrangement adopted in the Murray multiplex may be described as a compromise between the two methods. Cut forms are employed, but they are lightly tacked together with dextrin so as to overlap. They are also perforated along their sides like cinematograph films, so as to ensure positive feeding up to the point for starting the message. This arrangement works well, and it has the advantage that the receiving operator has merely to pull off the messages as they are finished. There is an absolute minimum of trouble in this respect. For the preparation of the message rolls beforehand, a punching tool is employed, which perforates 8 to 10 messages simultaneously. This is a quick and simple operation and a large number of messages can be perforated at trifling cost. Pasting the messages together into continuous rolls also presents no difficulties. The work can be done by a boy very rapidly by hand on a table without any mechanism; and in cases where large quantities are needed, a machine has been made to turn out the rolls quickly and cheaply.

TIME STAMP AND PRESS COPIER.

In the case of printing telegraphs handling a large number of messages, a time stamp saves a good deal of labor, and such an instrument is of special value in the case of a system like the Murray multiplex, where there is a possibility of one receiving operator attending to two printers, each producing 80 or more messages an hour. There is now at least one good time stamp on the market, and it is probable that such instruments will come into extensive use in connection with printing telegraphs during the next ten years. The time stamp will print on the telegrams instantly the date and time of reception, the number of the circuit, and any other particulars, including a number or other mark identifying the operator receiving and checking the messages. Actual experience has shown that an operator can easily check 120 messages an hour, and it is possible to check 150 an hour. With the aid of a time stamp it is believed that it would be easy to check 150 to 130 messages an hour. That is to say, except during times of great pressure, one operator would be able to attend to two multiplex printers, each turning out about 80 messages an hour.

There are a number of excellent wet-press copiers now in commercial use, and in time wet-press copying will overcome the trouble about keeping a copy for record of telegrams issued to the public. With a good multiplex printing telegraph such as that just described, and with a time stamp and press copying, the labor cost of telegraphy will be reduced to about the lowest point possible.

RESULTS WITH MURRAY MULTIPLEX.

It is too early yet to say positively what results can be obtained with the new Murray multiplex system, especially as there are still a number of detail improvements to be made. A complete installation has only recently been completed for the British Post Office, and is now being installed between London and Manchester. Prior to this, an experimental set, giving one transmission only, was made by the British Post Office, and tried for about six months between London and Birmingham. The results were surprisingly good. The sending operators were two girls without previous experience on typewriter keyboards, and yet within one month they were each punching 40 to 45 messages an hour. After about three months' practice each of these two girls succeeded in perforating 100 messages in one hour. Excluding several days when there were interruptions and breakdowns due to imperfections in the experimental apparatus, and excluding several days when traffic was light, the average number of messages on the one channel of transmission of the multiplex was over 80 per hour. On several days during busy hours the average exceeded 100 messages an hour. On one day, for instance, during three consecutive hours from 10 A. M. to 1 P. M., the numbers were 104, 126, and 102 messages per hour.

The Career of the Investigator.

By Professor W. B. Cannon, of Harvard University

[*In addressing the graduating class of the Yale Medical School last June, Prof. Cannon drew the attention of his listeners to the increased variety of services which at the present day invite the medical graduate to devote to them his lifework. Of the several careers thus thrown open, the speaker selected for detailed consideration that of the investigator, regarding which he quotes the beautiful words of Harvey: "Truly in such pursuits it is sweet not only to toil but to grow weary." We take a special pleasure in reproducing here from "Science" the essence of Prof. Cannon's inspiring address.*—ED.]

The investigator is first of all one who thinks as much of what we are ignorant of as he does of what has already been made clear. His chief interest is in the territory which has not yet been traversed. Indeed he is to be classed with explorers and pioneers.

For such men the complacent contemplation of things accomplished is intolerable—they chafe under the routine of established ways, and find the satisfactions of life in adventures beyond the frontiers. Harvey, among the first of modern discoverers, expressed the spirit of research when he wrote:

"It were disgraceful, with this most spacious and admirable realm of nature before us, and where the reward ever exceeds the promise, did we take the reports of others upon trust, and go on coining crude problems out of these, and on them hanging knotty and captious and petty disputations. Nature is herself to be addressed; the paths she shows us are to be boldly trodden; for thus, and while we consult our proper senses, from inferior advancing to superior levels, shall we penetrate at length into the heart of her mystery."

And in another place he wrote:

"Truly in such pursuit it is sweet not merely to toil, but even to grow weary, when the pains of discovering are amply compensated by the pleasures of discovery."

As children we all have an instinctive curiosity concerning the world about us, a curiosity which most of us gradually lose as we fit ourselves into the social conventions. The investigator is one, however, in whom this natural curiosity still persists. He has never got past the annoying stage of asking "Why?" The events occurring on every side which are matters of course to most men, startle him into wonderment. Why does the spinning top not fall? Why do animals breathe faster when they run? Why does disturbed water take the form of waves? Why do roots grow downward? Why does the mouth become dry when one speaks in public? Such are the questions that arise. The answers to them may be incalculably valuable to mankind. The microscope revealed to Pasteur strange organisms in bad-tasting wines. Why may not the disease of the wine, he asked himself, be due to the growth of these unusual germs within it? And later when he found germs also in silk worms, the further question was suggested. Why may not animals likewise become diseased in exactly the same manner? Whether the surmises of the investigator are true, the testimony of other men usually does not tell. He must turn to nature herself and put the idea to the test of observation and experiment.

This process of scientific inquiry involves peculiar qualifications which can not be disregarded by any one who thinks of trying it. Research implies in the first place *seeking again* over a region which has been previously traversed in order to learn what other men have done and the point where their labors ended.

To make progress sure, therefore, previous records must be carefully studied. The failure to pay this just tribute to those who have labored before has not seldom led to fruitless effort or to vain repetition of work already well done. Marking the boundaries demands, then, a scholarly acquaintance with earlier discoveries; and the painstaking methods of the scholar must be used.

An ingenious and inventive imagination is a second requirement. It serves to indicate where the problems lie and also to suggest possible methods for solving them. The mind must be hospitable to all ideas thus presented, and yet it must receive them with skeptical scrutiny. By critically considering a plan for solving a problem it is often possible to select central tests, which are strategically related to the logic of the entire research. The physiologist Goltz is said to have done his most important work while fishing, for he employed that time in devising the crucially significant experiments.

Not all inquiries, however, can be ended by a relatively small number of crucial tests. Some investigations, like the important breeding experiments of De Vries, require years before they can be brought to a conclusion. Patience and an enthusiasm which is intelligently persistent are therefore essential qualities for the man in quest of new truths. The hopeful spirit is especially needed when, at the end of a long search, the investigator finds that he has only his labor for his pains—when his leading idea has proved to be false. That disheartening event is what Huxley called the tragedy of science—"the slaying of a beautiful hypothesis by an ugly fact."

The very soul of research, finally, is the highest degree of honesty. The investigator should see clearly and accurately with an eye single to the truth. He has to consider not only the observations which fit his theory, but any others as well. The erratic cases invariably make trouble, but they are often disguised blessings. They may indeed be of far greater moment than those which have been anticipated, for they may point the way to entirely unsuspected facts.

In my early sudies on digestion I well remember how much I was annoyed by the repeated failure of some animals to show any signs of digestive activity during the period of observation. You can imagine how suddenly my vexation changed to deep interest when the troublesome inhibition was found to be an accompaniment of fright or anxiety which these animals showed while being looked through with the X-rays.

After the investigator has completed his examination of a group of questions which have interested him, his leading idea, his tests and his results must be described with scrupulous exactness. In thus reporting his work he should strive to be like clearest crystal, receiving the light and transmitting it untinged by any trace of color.

Scientific activity implies, of course, thorough disinterestedness. The investigator asks no favors and renders none. Any intimation that he act as a retainer or special pleader, any hint or suggestion that he injure cherished traditions, is a step toward the confinement of the free spirit of intellectual inquiry. Rather than surrender that freedom of inquiry or the right of untrammelled announcement of fresh discoveries, men of science have in the past submitted to tortures and painful death, and you may be sure that, if need be, they will be ready to sacrifice themselves again. So exalted is the regard in which the man of science holds the ideal to which his life is devoted that he would find in these words of Fichte his solemn pledge:

"To this I am called, to bear witness to the Truth. My life, my fortunes, are of little moment; the results of my life are of infinite moment. I am a Priest of Truth; I am in her pay; I have bound myself to do all things, to venture all things, to suffer all things for her. If I should be persecuted and hated for her sake, if should even meet death in her service, what wonderful thing is it I shall have done—what but that which I clearly ought to do?"

The satisfactions of a life devoted to investigation, like the satisfactions of other careers, arise from the profitable use of one's powers. The peculiar powers which are needed for research I have just described. The employment of these powers in perfect freedom, and the immeasurably important results that flow therefrom, render the satisfactions of productive scholarship especially keen. These satisfactions we may now consider in relation to the special qualifications of the investigator.

The requirement that the investigator learn what other men have done before him in the field he seeks to enlarge gives him an unusual realization of the part he may be playing in the promotion of natural knowledge. Knowledge grows like the picture in the dissected puzzle. Every addition must fit the parts already arranged in order to possess significance, and also every addition makes possible the fitting of new parts whose positions in the enlarging picture become thereby suddenly revealed. One of the delights of research, therefore, is the sense that every bit of new knowledge finds its place in the structure of truth, and that sooner or later it will be required for the further building of that structure. The relation which the fresh contribution bears to that already established, the discoverer clearly sees; what relation it will certainly bear to further contributions he may never know. How little did the men who studied the minute differences among mosquitoes, and who recorded the breeding habits of those insects realize their important rôle in abolishing the pestilence of yellow fever, and in bringing about the immense social and political changes which will result from that conquest.

Because every discovery becomes the basis for further discovery the imagination of the investigator is constantly stimulated. New facts suggest in turn other facts and point to unsuspected relations between things that have long been known. Bayliss and Starling's discovery of a natural chemical stimulant which induces secretion of the pancreas led directly to the explanation of continued gastric secretion, and also to finding the marvelous mechanism by which the mammary glands are prepared for the giving of milk. Thus, though the interests of the man of science seem at the moment narrow and restricted, they may nevertheless lead his thought out into many diverse realms of knowledge. These excursions of the imagination offer repeated suggestions for fresh adventure. The look therefore is always forward to what may be seen when the next step is taken. Seeking new things becomes in time a fixed habit. Past achievements neither satisfy interest nor hold attention—they become fused with the established routine from which it is a happiness to escape. The chance of beholding unsuspected wonders, or the possibility of finding that something imagined is really true is a constant incitement to further search and furnishes the zest and interest which are among the best rewards of the investigator.

Much happiness is found also in that single-mindedness, which, as we have seen, is one of the prime conditions in the pursuit of knowledge. It implies freedom from bigotry and prejudice, freedom from many of the influences and motives that to their regret men feel compelled to respect for purposes of prudence or policy. The intrusion of any other motive, save that of discovering and telling the truth, only tends to distract the mind of the investigator from his absorbing work. Faraday, whose life as a man of science was near perfection, wrote:

"Do not many fail because they look rather to the renown to be acquired than to the pure acquisition of knowledge and the delight which the contented mind has in acquiring it for its own sake? I am sure I have seen many who would have been good and successful pursuers of science and have gained themselves a high name, but that it was the name and the reward they were always looking forward to—the reward of the world's praise. In such there is always a shade of envy or regret over their minds, and I can not imagine a man making discoveries in science under these feelings."

Single-mindedness involves also a relative indifference to those motives of money-getting which prevail in commercial life. Success in research is fortunately not measured by money standards. And yet research flourishes best where there is free time to spend in thought and experiment. This time element is essential. The investigator may be made to dwell in a garret, he may be forced to live on crusts and wear dilapidated clothes, he may be deprived of social recognition, but if he has time, he can steadfastly devote himself to research. Take away his free time, and he is utterly destroyed as a contributor to knowledge.

Free time and absence of the money motive, however, are found together only among the indolent poor and the indolent rich; and the observation has been made that neither of these classes is likely to contribute men of science. The industry of the investigator which results in new knowledge—knowledge in its unprofitable infancy—does not possess commercial value. Until recently indeed any money value of research had not been recognized. In the unappreciative past deplorable instances were known of struggles with poverty and want, going hand in hand with persistent loyalty to truth-seeking. Now, however, accumulated wealth is giving leisure for men to carry on their investigations free from the worries of uncertain livelihood. What they receive may not be much, but it is sufficient to permit them to look upon the scramble for wealth without envy or regret.

Fortunately, the provisions which enable men to pursue careers in science are found mainly in great universities, through which a stream of youth is constantly passing. There men who are moved by the instinct of investigation usually find their most congenial surroundings. Freedom of inquiry is the ancient tradition of the university spirit, leisure is recognized as a requisite for meditative observation, and the youth who resort to these centers of learning can be awakened to wonder at nature's hidden secrets, and can be stimulated to undertake with ardor the struggle to possess them. The peculiar richness of university life flows from memories of the transforming powers of the progressive and original minds who have by their eagerness for the truth and their freedom from worldliness inspired their students with their own ideals.

The greatest compensation, after all, for the truth seeker is the discovery of the truth. The value of labor that brings a revelation of new knowledge does not cease with the day; it remains as a permanent acquisition for the race. There is really great satisfaction to the investigator in this thought of the "durable results of the perishable years." But not only because of the permanence of truth is there pleasure in discovery—it is the marvel of beholding for the first time an unknown aspect of nature that fascinates men of science, and through difficulties and repeated disappointments holds them to the search. Only he who has had the experience knows the thrill that comes when that which was imagined proves to be true. One who was in Faraday's laboratory when the influence of the earth's magnetism on a wire conducting an electric current was first tested, has written: "All at once Faraday exclaimed, 'Do you see, do you see, do you see!' as the wire began to revolve, and I shall never forget the enthusiasm expressed in his face and the sparkling in his eyes." Kepler knew the joy which rewards the scientific discoverer when he completed the evidence that established his third law of planetary motion. Even one whose pulses have not quickened with the excitement of discovery can understand perhaps how he must have felt as he burst into triumphant exultation:

"What I prophesied two-and-twenty years ago, . . . what sixteen years ago I urged as a thing to be sought, . . . that for which I devoted the best part of my life to astronomical contemplations, at length I have brought to light and recognized its truth beyond my most sanguine expectations. It is not eighteen months since I got the first glimpse of light, three months since the dawn very few days since the unveiled sun burst upon me. Nothing holds me; I will indulge my sacred fury. If you forgive me, I rejoice; if you are angry, I can bear it. The die is cast, the book is written, to be read either now or by posterity, I care not which. It may well wait a century for a reader, as God has waited six thousand years for an observer."

The scientific investigator may not seek particularly for knowledge which can meet at once some material need. Like the artist, he is more prone to direct his effort toward that which will for the moment properly gratify an absorbing interest of his mind. If the new knowledge has, when discovered, an immediate practical value, so much the better; but the direct search for understanding has certainly always proved the most effective motive in scientific labors. Because of this attitude the investigator should not be regarded as self-centered, or neglectful of duties to the general good. He is serving best his own generation in so far as he makes his standard of work thorough and honest. In so far as he does that, he is serving best future generations as well, for only thus can the results of his work be used later as a basis for further advancement. And since the interrelations of phenomena are so manifold the conviction is justified that every bit of honest work can finally be utilized in forming the body of truth. Although the investigator may labor, therefore, primarily to satisfy his own curiosity, and to secure for his craftsmanship that inner approval sought by every conscientious worker, nevertheless he is making permanent additions to the world's values. There is about his life, as Prof. Royce has noted, 'an element of noble play. . . . One plays with silk and glass and amber, with kites that one flies beneath thunder clouds, with frog legs and with acid. The play is a mere expression of a curiosity which former centuries might have called idle. But the result of this play re-creates an industrial world. And so it is everywhere with our deeper curiosity. There is a sense in which it is all superfluous. Its immediate results seem but vanity. One could surely live without them, yet for the future and for the spiritual life of mankind, these results are destined to become of vast import."

Sometimes the worker in science lives to see his services used for the relief of human need. When Davy's studies of combustion enabled him to invent the safety lamp, he gave the invention freely to the world. He knew then that thenceforth for all time toilers in the mines could protect themselves against the dangers of destruction. There is no realm, however, in which the deep satisfaction of seeing discovery applied to human service is more likely to be experienced than in the realm of medical research. Consider how great must have been the joy of Pasteur and of Lister when they realized that the consequences of their investigations must lessen forever plague and pestilence and pain in men, and in the lower animals as well, and must permanently remove much of the blind struggle against mysterious agencies of disease and death. The letter which Walter Reed wrote to his wife on New Year's eve, 1900, at the end of his experiments on the transmission of yellow fever, tells something of the joy of such service—"The prayer that has been mine for twenty years," he concludes, "that I might be permitted in some way or at some time to do something to alleviate human suffering, has been granted! A thousand Happy New Years." And a thousand happy new years there will be for thousands of men and women and children, because of that one research in Cuba.

Through the employment of methods of scientific inquiry to medical problems more progress has been made during the past sixty years toward an understanding of the nature of diseases and their control than had been made in the previous twenty-three centuries. Think for a moment of what has been learned about diphtheria and tetanus, about meningitis and rabies, about tuberculosis and syphilis, about dysentery and cholera and typhoid fever. How fundamentally our attitude toward these diseases has altered as the discoveries of medical investigators have given us insight and powers to control. What great progress we have already made in this relatively short period toward the relief of man's estate. Still we must not forget that there are immense labors yet to be accomplished. We are yet surrounded by innumerable mysteries, which can only be solved by persistent research. Not all men are fitted by temperament or training to engage in this great work, but more are thus fitted, I am sure, than are awakened to its opportunities. For those of you who are ready, here is a challenge to the supreme use of all your powers—to your imagination, your ingenuity, your patience and enthusiasm, and to your spirit of disinterested service.

Mechanical Service for the Furnace i

Conveyors and Chutes for Feeding the C

THE handling of coal and ashes in the modern power or electric light station and gas plant is accomplished in many instances by the same conveyor, the equipment being automatic in operation and little or no hand labor being required about the plant even where the station is of the largest size.

In the accompanying drawings Figs. 1 and 2 show the power house equipment of the Union Gas & Electric Company and the arrangement of the endless overlapping lip pivoted bucket conveyor and elevator of the Jeffrey type, Fig. 2 being a section through the power house and indicating the method of handling the coal and ashes by the same conveyor.

It will be noted that the coal is received at *A* from which it is fed to the crusher *B*, and then into the pivoted bucket conveyor *G*, which carries it up into the coal bunker. The ashes are collected in the hopper *D* as noted in drawings Figs. 1 and 2 and when the conveyor *G*, is not handling coal the ashes are fed into it and carried up into the ash bucket.

Another method of handling coal and ashes as used at the power plant of the Peoria Gas and Electric Company is of some interest. At this plant the coal is taken directly from the cars at or from a storage pit by a grab bucket which discharges into a hopper. After being crushed the fuel then passes to a belt conveyor which is discharged by means of a reversible tripper into the coal bucket. The ashes are simply wheeled by hand in barrows, and dumped into a pit, from which they are transferred to railway cars by means of the grab bucket.

One of the most up-to-date coal handling equipments in operation in American gas and coke plants is that of the Dayton Gas Light and Coke Company shown in the accompanying illustrations, Figs. 3 and 4. The coal is elevated from the track hopper by a flight conveyor and passes through a Jeffrey crusher to a pivoted bucket carrier in a tunnel below the storage building. This tunnel and bucket conveyor are shown in Fig. 3, which is a view looking along the tunnel toward the crusher.

The upper run of the conveyor in the storage house is seen in Fig. 5, which also shows the oiler in the fore ground and a bucket being automatically unloaded just beyond. There is a pivoted bucket conveyor between the storage house and the retort house, driven through gears by the storage conveyor.

The coal handling installation at Dayton consists in the main of two 24-inch by 18-inch bucket conveyors running in planes at right angles to each other at a speed of 50 feet per minute and capable of handling 50 tons of coal per hour.

It may be stated that the first conveyor in the coal storage house of the plant is a "run-around" with 104 feet of horizontal and 43 feet of vertical travel. As shown in the accompanying illustration and mentioned above the lower horizontal run is in a concrete tunnel beneath the storage house floor and the upper horizontal run is in a monitor above the roof of the building, the power for operating this conveyor being furnished by a 14 horse-power engine located in the tunnel.

It is of interest to note the route of the coal as it is handled by this equipment at the Dayton plant. In the first place the railroad cars are shunted into the storage building, and dumped into a steel track hopper twelve feet square, from which the coal passes to a flight conveyor of 16-foot centers. This conveyor is driven through a chain and jaw clutch from the take-up shaft, and rising with an incline of 30 degrees discharges the coal into a 24-inch by 30-inch crusher.

In case small coal is handled a by-pass valve diverts the flow of coal around the crusher to the hopper below, thus allowing the engine driving the crusher to be shut down. At the bottom of the hopper beneath the crusher is a loading device to automatically deliver the coal to each of the pivoted buckets. The coal is then conveyed to the upper horizontal run, where a traveling tripper discharges it at any point required to the storage bunkers.

When it is desired to reclaim the coal from storage to the conveyor, it is passed through reclaiming chutes, or spouts, located at intervals in the top of the concrete tunnels, to automatic loaders, and thence to the lower horizontal run of the first pivoted bucket conveyor. When this conveyor is not storing it discharges into a chute placed at the end of the upper horizontal run, this chute delivering through an automatic loader to the second pivoted bucket conveyor.

The second conveyor is driven through chain and miter gears from an upper corner shaft of the first conveyor and a remarkable feature of this carrier is a sharp elevation of six feet in a single thirty-degree incline which demonstrates to some extent the elasticity and adaptability of this form of conveyor.

Two simple and efficient installations for handling coal and ashes are illustrated in drawings, Figs. 5 and 6, which represent the method of operation at the Globe-Wernicke power house and the Brower & Love plant.

The view presented in Fig. 7 shows how the coal is

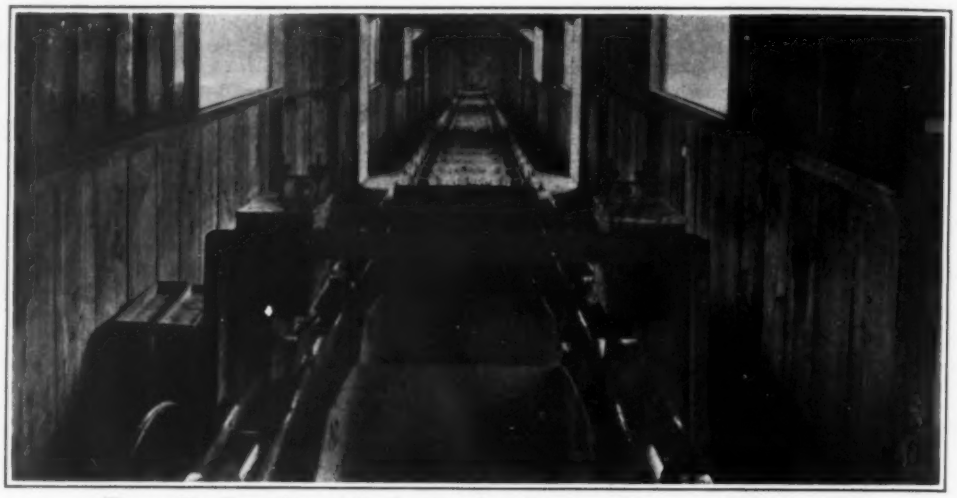


Fig. 4.—The Upper Run of the Conveyor in the Storage House of the Dayton Works.

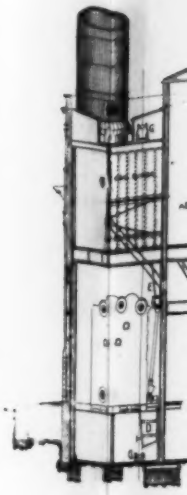


Fig. 1.—Coal-Handling Equipment at
of the Union Gas and Elec

Fig. 7.—Coal-Chutes Supplying Boilers and Ash Hoppers at Brower and Love Plant.

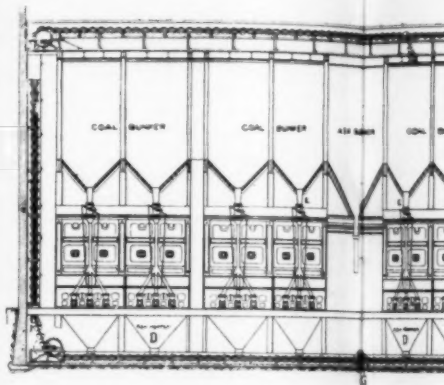


Fig. 2—Automatic Coal-Conveyor at the Union

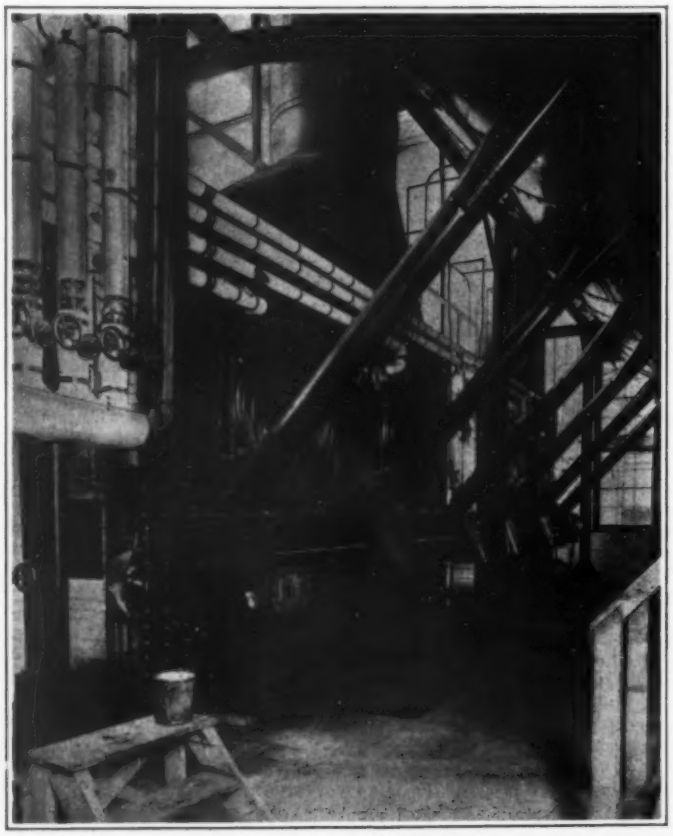


Fig. 10.—Chutes and Valves for Taking Fuel Directly from the Coal Bunkers to the Stoker at the Globe-Wernicke Plant.

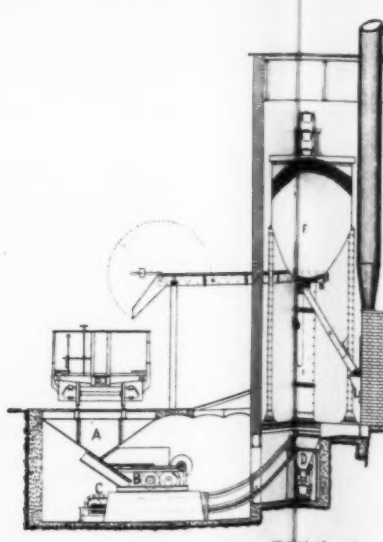


Fig. 5.—Coal-Handling at the Globe

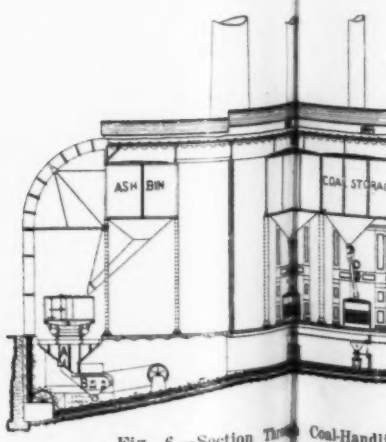
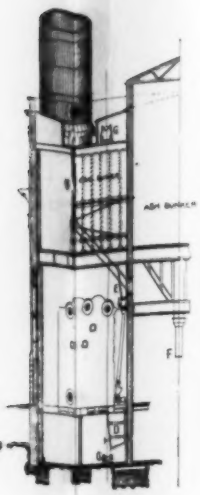


Fig. 6.—Section Through Coal-Handli
at the Brower and Love

urnace in the Modern Industrial Plant

Feeding the Coal and Removing the Ashes



-Handling Equipment at the Power House the Union Gas and Electric Co.

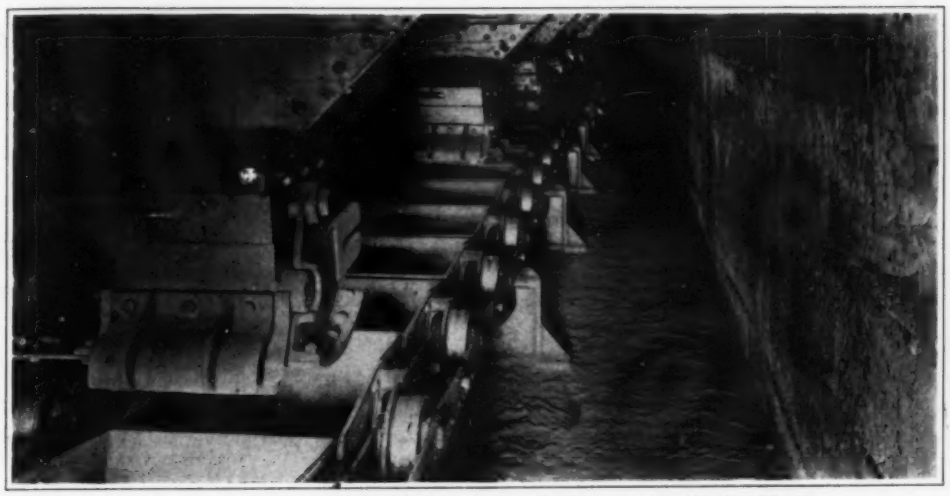
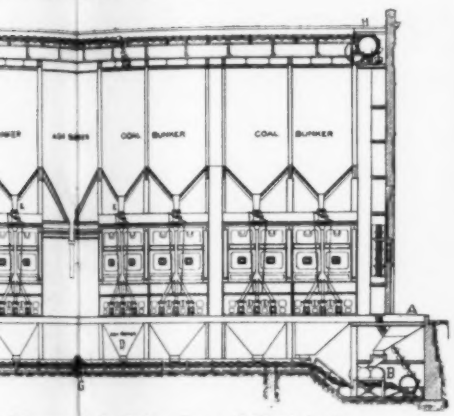


Fig. 3.—In the Tunnel Under the Storage Building at the Dayton Works.



al-Conveyor at the Union Gas and Electric Co.

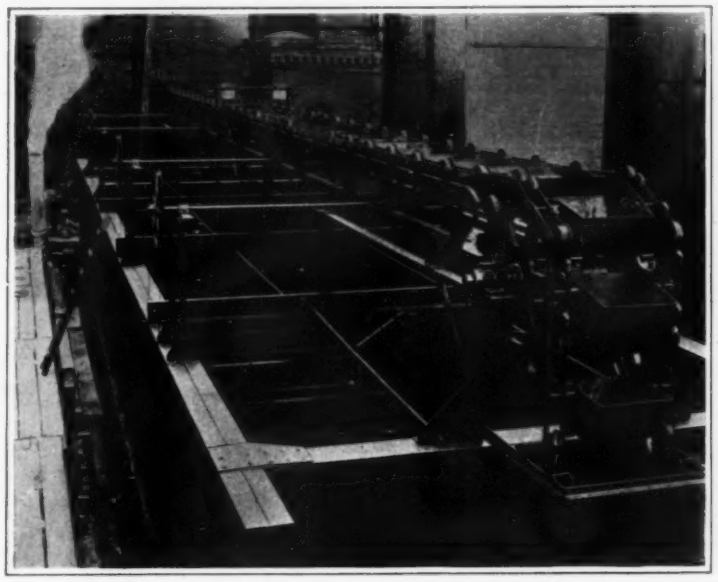
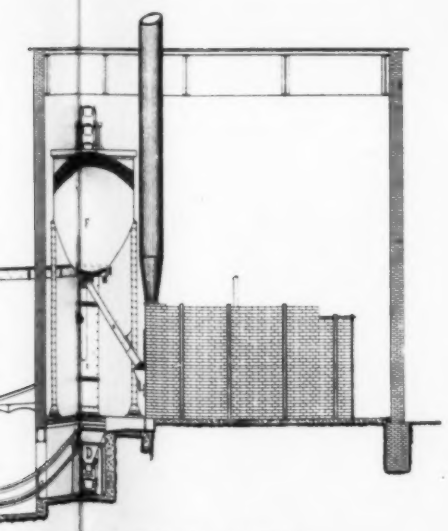
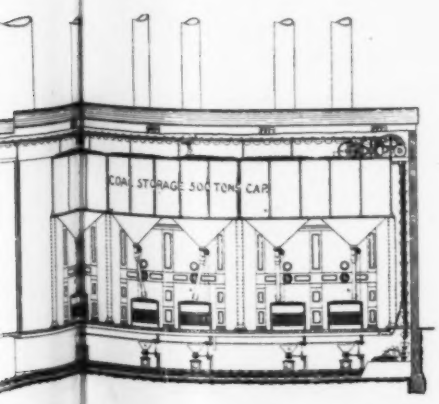


Fig. 8.—Bucket Conveyor Over the Coal Bins in Power House of the Globe-Wernick Co.



Coal-Handling at the Globe-Wernicke Plant.



ection Through Coal-Handling Installation at the Brower and Love Plant.

Fig. 9.—Ash-Handling Train Under the Boilers of the Globe-Wernicke Plant.

supplied to the boilers and the ashes are withdrawn from under the boilers. They are transferred to the main pivot bucket conveyor of the Jeffrey type as indicated in drawing Fig. 6, and from that carried into the ashes storage bin noted at the left. From here this waste material is loaded into the cars on the track below.

At the Brower & Love plant the coal is handled in the following manner: The fuel passes from the cars on the track into the hopper *A*, Fig. 6, then to the crusher *B*, and by means of the coal loader indicated unto the pivoted bunker of 500 tons storage capacity. It will be seen that the same conveyor is also utilized for handling the ashes, which are withdrawn from under the boilers by means of a screw conveyor and then carried into the ashes storage bin by the rain bucket conveyor.

At the Globe-Wernicke boiler plant the coal is brought into the installation in cars as indicated in drawing Fig. 5, the fuel passing into the hopper *A* and then into the crusher *B*. The crushed coal is carried by means of the conveyor *C* to the loader *D* and from the loader it is elevated by the pivoted bucket conveyor and discharged into the coal bunker *F* over the stoker. Trippers are used to discharge the coal from the buckets, the entire equipment working automatically.

At the boiler house the ashes are taken away by the same conveyor when the latter is not delivering coal, and the waste material is discharged into the ash hopper from which a spiral conveyor carries the ashes to the cars. The illustration Fig. 8 shows the bucket conveyor over the coal bins in the power house of the Globe-Wernicke Company, while Fig. 9 shows the ash handling machinery under the boilers, the chutes and controlling valve for conveying and handling the fuel directly from the coal bunkers to the stokers in the boiler room being indicated in the accompanying illustration, Fig. 10. By means of these labor saving devices all the fuel and ashes of the modern power plant are handled with little or no hand labor, machinery being employed for moving and feeding the coal from the time it arrives in the cars to its consumption in the boiler and the final delivery of the ashes to the storage bin

The Velocity of Rontgen Rays.

ABOUT six years ago Erich Marx found that Röntgen rays traveled as fast as light rays, which had generally been assumed for general reasons. The experimental method of Marx was attacked, however, and the complicated character of the apparatus certainly justified some doubt. Marx has, therefore, repeated his determinations. The new experiments are based upon the same principle; but the apparatus is simplified, and the method is modified. The result is the same as before. Röntgen rays appear to travel with the velocity of light rays, the rate being the same within a few per cent. The first method was a zero method, depending upon the appearance of sparks. The advantage of this method was that details of the character of the sparks need no more be known than the observer sitting in front of a balance need know the direct connection between the load applied and the produced deflection of the beam; it is sufficient for him to see that the beam is deflected. In the new experiments a zero method is not used; the apparatus is simpler, the arrangements are more lucid, and long waves are excluded; but short waves of relatively very high energy are required, and extreme care is necessary throughout the experiments. As in the first determination, two coherent trains of waves are made to act upon each other. Hertzian waves of considerable frequency are excited, and travel along a Lecher system of wires, consisting of two parallel wires with a movable bridge-piece. They first strike a Röntgen tube, and produce periodical impulses of Röntgen rays; this is the first train of waves. The other train is inductively coupled with the first. It travels along a wire to an electrode mounted in a vacuum bulb; this electrode will oscillate in synchronism with the Röntgen rays, but will lag behind in phase; the phase difference depends upon the position of the bridge. The two trains interfere with each other, and the interference is observed. Opposite the electrode is mounted, within the bulb, a Faraday cage containing an electrometer. When the Röntgen rays strike the electrode at a moment when their potential is negative, a spontaneous discharge takes place; when the potential happens to be positive, no discharge will be observed. The current wave observed should have two maxima. When the bridge is shifted the maxima of the second wave will appear to be displaced with regard to the maxima of the first wave. This displacement Marx finds to be equal to the distances through which the bridge has been shifted. He concludes, hence, that the velocity of the Röntgen rays is the same as that at which the electric waves travel along the Lecher wires, which is known to be the same as that of light in air.

Simple Experimental Evidence for the Presence of Ions*

A Schedule Adapted to the Resources of the Small Laboratory

By Charles W. D. Parsons, Northwestern University

THE following experiments have been planned for the purpose of demonstrating in a simple manner some of the essential phenomena of the ionization of gases. The needs of the teacher of physics have been kept in mind and the apparatus is in all cases of the very simplest type, including practically nothing outside of the resources of a fairly well-equipped laboratory.

I. CONDUCTIVITY OF GASES FROM FLAMES.

EXPERIMENT 1. Arrange the apparatus as in Fig. 1. *A* and *B* are two metal plates of any convenient size. (In the experiments here described they were of brass about 10 centimeters (3.94 inches) in diameter supported by clamps on ordinary ring stands). *A* is grounded through a water pipe; *B* is insulated from the table by a sheet of hard rubber, and connected by a wire to the knob of a gold-leaf electroscope, *G*, whose case is also grounded. If a Bunsen flame is held at *F*, even some distance below the plates, so that the gases from the flame enter the space between the plates, the electroscope, whether positive or negative, will be found to discharge almost as if *A* and *B* had been joined by a wire. This discharge will take place even if *A* and *B* are more than 15 centimeters (5.91 inches) apart.

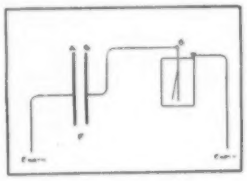


Fig. 1.

Explanation. The gaseous products of combustion have come from the flame in an ionized condition, i. e., some of the molecules have an extra negative electron of which others have therefore been deprived. Suppose plate *B* to have a negative charge. Plate *A*, being grounded, will have an induced positive charge. When the ionized gas enters the strong field between the plates essentially the same thing happens as in the electrolytic cell. The positive ions go to plate *B*, receive from it the electrons of which they are deficient, and so discharge the electroscope; the negative ions go to plate *A* and give up their electrons. There is thus a true current or transfer of electricity through the gas.

To account for the ionization of the gas we may say that some of the molecules have attained sufficient velocity in the heated gas to disengage an electron, and thus become positive ions. This electron attaches itself to another molecule and so a negative ion is formed. From experiments on the velocity of these ions it is evident that their masses must be greater than that of a single molecule, a fact which is explained on the supposition that an ion may attract to itself several neutral molecules, and thus increase its mass without increasing its charge, the aggregate acting as a single ion.

EXPERIMENT 2. Allow the flame to touch both plates simultaneously. The discharge will be almost instantaneous.

Explanation. Ions are present in large numbers in the flame itself, as the explanation of Experiment 1 suggests.

EXPERIMENT 3. Place the flame at the side of or even above plates *A* and *B* when they are 2 or 3 centimeters (0.79 inch or 1.18 inches) apart. The discharge still takes place.

Explanation. "The electric field due to the charged conductor drags out of the flame and up to the conductor ions of opposite sign to the charge."[1]

EXPERIMENT 4. Remove the plate *A* altogether and bring the flame near plate *B*. The discharge will take place, but more slowly. The plate is, of course, not necessary, for the electroscope can be discharged by simply bringing the flame near its knob.

Explanation. The slower discharge is accounted for by the fact that the intensity of the field near plate *B* is not so great as when plate *A* was present, and therefore the travel of the ions to it is not so rapid.

EXPERIMENT 5. Add to the apparatus shown in Fig. 1 another pair of plates, kept at as large a difference of potential as is available. (In Fig. 2 the arrangement is shown with plates *C* and *D* the terminals of a direct current 110 volt circuit.) Have plates *A* and *B* say 12 millimeters (0.47 inch) and *C* and *D* 15 millimeters (0.59 inch) apart. Place the flame at *F* and close enough to plates *C* and *D* to prevent heated gases passing to *A* and *B* around the outside of the two plates. When the switch, *S*, is open

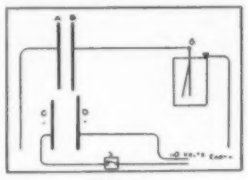


Fig. 2.

the electroscope will be discharged as in Experiment 1. Close the switch and the fall of the leaves instantly stops. Open the switch and it begins again.[2]

Explanation. The ions from the flame act when between the charged plates *C* and *D* just as they did between *A* and *B* in Experiment 1. They are therefore withdrawn from the gas, which is then free from ions when it reaches *A* and *B*, and so is unable to discharge this pair of plates. That the ions actually complete the circuit and establish a current between the plates will be shown in the next experiment.

EXPERIMENT 6. Place in the circuit of plates *C* and *D* and the 110 volt terminals[3] a sensitive galvanometer, *G*, and a reversing key, *K* (for use in the next experiment). The arrangement is shown in Fig. 3. Place the flame below but not touching the plates. A slight current will be indicated by the galvanometer. Allow the flame to touch both plates and a stronger current will result. While the flame is still touching the plates place in it a piece of asbestos which has been soaked in brine, and the conductivity will be much increased.[4]

EXPERIMENT 7. An interesting modification of the above experiment consists in placing the plates 15 to 20 millimeters (0.59 to 0.78 inch) apart and allowing the flame to fall upon one side only of the space between them. This may be done by placing the burner directly beneath a plate so that the flame is divided and falls part between and part outside of the plates, or by inclining the flame so that it falls on the inner face of one of the plates. Care must be taken not to let the flame touch both plates at once. Here we meet with our first evidence of unipolar effects. The current will always be less when the flame is at the

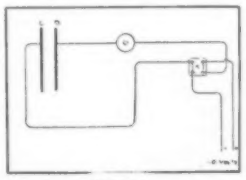


Fig. 3.

positive plate than when it is at the negative plate. Either plate may be made the positive pole by use of the commutator, *K* (Fig. 3), and the above effect thus be shown to be independent of slight differences in the nature of the plates.

Explanation. When the flame is near one plate the ionization is mostly confined to that region, and the ions of sign like the plate, being repelled, are the ones which carry the current between the plates, the ions of opposite sign being attracted directly to the nearest plate. Our experiment points to the fact that the negative ions are better carriers of electricity than the positive ions.

For an explanation of this fact we must add an hitherto unmentioned difference between the ions. Experiments on their velocity show that in a field of given intensity the negative ions have a velocity several times as great as that of the positive ions.[5] This being true, there will evidently be a greater transfer of electricity in a given time (i. e., a stronger current) when the negative ions are carriers than when the positive ions carry the current.

II. IONIZATION BY INCANDESCENT SOLIDS.

EXPERIMENT 8. Place 2 or 3 centimenters (0.79 inch or 1.18 inches) of fine platinum[6] wire in series with a storage cell and an adjustable rheostat. Support this wire at a distance of 5 to 10 millimeters (0.197 to 0.394 inch) from the knob of a gold-leaf electroscope. Charge the electroscope negatively and adjust the current until the wire shows a dull red glow. The electroscope will be rapidly discharged. Shut off the current and recharge the electroscope. Heat the wire rapidly to a brilliant incandescence and the discharge will also be rapid. Repeat these two experiments with a positively charged electroscope and it will be found that the dull red wire has no effect on the charge, while the incandescent wire causes a rapid discharge of the electroscope.

Explanation. The hot wire is evidently giving off ions. When it is red hot only positive ions are given off, while from the white hot wire both positive and negative ions are being discharged. In the latter case the electroscope, whatever its sign, attracts ions of the opposite sign and so becomes discharged, while with the red hot wire and the positively charged electroscope such action is impossible on account of the lack of negative ions.

Note. The emission of positive ions from a red hot wire depends greatly on the previous history of the wire, so that if results are not obtained it may be necessary to take a new wire.[7]

EXPERIMENT 9. Support a platinum crucible on its side in a ring-stand clamp. In a clamp on another ring-stand fasten a flat strip of metal. Make the two

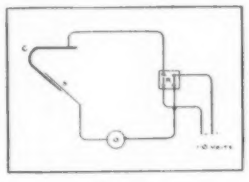


Fig. 4.

stands the terminals of a 110 volt circuit in which is included a reversing key and a sensitive galvanometer. Insert the metal strip well within the crucible and make the crucible red hot with a Bunsen flame. No current passes. Reverse the poles and the galvanometer will be deflected an appreciable amount.

Explanation. This result confirms the result obtained above with the red hot wire. There is a tendency to emission of positive ions, which cannot escape from the crucible when it has a negative sign, but which readily carry the current from the crucible to the strip when the sign of the former is positive. The arrangement of the crucible as suggested above prevents complications from the ionization due to the flame such as would occur if the crucible were placed upright and heated. In our experiment the gases from the flame do not come near the strip *S*.

III. IONIZATION BY RONTGEN RAYS.

EXPERIMENT 10. To show the ionizing power of Röntgen rays arrange the apparatus as in Fig. 5. *C* is a Crookes's tube operated by an induction coil, *I*, and inclosed in a lead-covered box, *L*. This box may be open on one side for the insertion of the wires from the secondary of the coil, and should be so large that there can be no discharge from these wires through the lead covering of the box. The lead may be the "tea-lead" used to line the inside of tea chests.

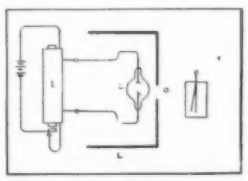


Fig. 5.

Several thicknesses will probably be necessary to act as an effective screen for the rays. At *O* is an opening through the box opposite the anode at which the Röntgen rays originate. (A one-inch auger hole will do.) Charge a gold-leaf electroscope either positively or negatively and move it about in the region to the right of the box, *L*. As it comes within the range of the rays which pass through the opening, *O*, the leaves will rapidly collapse, while outside of this restricted space they will be stationary. (There may be slight motion of the leaves caused by the too close proximity of the induction coil, the imperfect separation of the

* *School Science and Mathematics.*

[1] J. Thomson, "Cond. of Elec. through Gases," p. 229.

[2] Results may be obtained by connecting *C* and *D* with the knobs of a Toepler-Holtz or other static machine.

[3] With a very sensitive galvanometer results may be obtained with even a single dry cell.

[4] See articles by H. A. Wilson, "Phil. Trans. A," 192, p. 499, 1899; "Phil. Mag.," VI. 4, p. 207, 1902.

[5] H. A. Wilson, "Phil. Trans. A," 192, p. 499, 1899.

[6] Fine iron wire will do, but gives trouble by too rapid fusing.

[7] J. J. Thomson, "Cond. of Elec. through Gases," p. 213.

lead covering from the high potential wires, or the lack of sufficient thickness of lead to totally screen off the rays.)

Explanation. The rays striking on the gas surrounding the knob of the electroscope cause ionization of this gas and the electroscope is discharged exactly as in Experiment 1. The ionization of the gas is probably due to the disengaging of electrons from some of its molecules by the impact of the ether pulses of which the Röntgen rays consist.

EXPERIMENT 11. Place the electroscope outside of the range of the rays from the opening *O*, and by means of a foot-bellows and piece of gas tubing blow air from near the opening against the knob of the electroscope. The discharge readily takes place whether the leaves are charged positively or negatively.

Explanation. This shows that the collapse of the leaves is not due to the direct action of the rays on the electroscope, but that it is the ionized air which causes the discharge.

EXPERIMENT 12. Place a metal cap over the knob of the charged electroscope to protect it from the discharging action. Allow the rays to fall upon the gas inside the electroscope through the glass side of its case. The electroscope becomes discharged.

Explanation. From this experiment it is evident that the Röntgen rays possess ionizing power after passing through several millimeters of glass. This penetrating power of the rays differs greatly with the condition of the Crookes's tube in which they are generated.[9]

EXPERIMENT 13. Replace the knob of the electroscope with a knob inclosed in an air-tight vessel provided with two openings, as shown in Fig. 6. (For details of construction see the note at the end.) The position of the opening *E* of the inlet tube *T* that will give best results should be found by trial, as the success of the experiment seems to depend in great measure on its being properly located. A position about 5 millimeters (0.197 inch) above the top of the knob has given best results with apparatus of the dimensions described in the note. For observing the comparatively slow discharge of the leaves in this and succeeding experiments a micrometer microscope

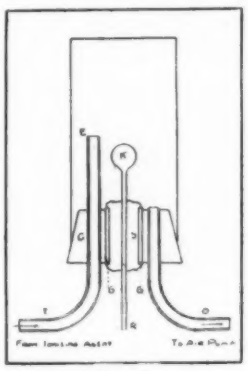


Fig. 6.

should be used, although a reading telescope focused on a scale placed back of the electroscope will give fairly good satisfaction. The air pump may be a Bunsen filter pump or an ordinary piston air pump. The former gives steady but slow action; the intermittent action of the latter is compensated for by the more noticeable movement of the leaves.

To prevent further disturbances of the leaves due to the presence of the induction coil and the wires leading from it to the Crookes's tube, it will be almost absolutely necessary to surround the electroscope with wire netting.

If the inlet tube is too short the electroscope may be affected by X-rays which have penetrated the lead covering of box *L*, Fig. 5; if too long, the discharge will not be rapid enough. The proper medium must be found by trial. Place the outer end of the tube *T* in the air which has been acted on by the Röntgen rays and work the air pump. If all the precautions mentioned above have been taken, the leaves will slowly fall together.

IV. IONIZATION BY RADIO-ACTIVE SUBSTANCES.

EXPERIMENT 14. Repeat Experiments 1, 3, and 4, using for the ionizing agent a small amount of some radio-active substance placed near the plates. In the experiments described a small amount of radium bromide crystallized on a microscope slide was used at first. Later it was found that good results could be obtained by using the "pointer" of a Crookes's spinthariscope. The discharge of the electroscope will be fairly rapid.

EXPERIMENT 15. Repeat Experiment 13 with a radio-active substance placed near the mouth of the inlet tube. The discharge takes place as before.

[9] J. J. Thomson, "Cond. of Elec. through Gases," p. 644.

Explanation. The rays given off by the radio-active substance evidently possess the power of ionizing a gas. The nature of these rays it is beyond the scope of the present paper to discuss.

EXPERIMENT 16. Repeat Experiment 15 with a small plug of glass wool[9] or even cotton wool in the tube. Make a slight constriction in the tube by heating it in the Bunsen flame and drawing out gently. This will keep the wool from being drawn down the tube. The pump should be worked a little harder to insure the entrance of the air at the same rate as before the insertion of the wool. Notice that the discharge of the leaves is prevented.

The effect may be made more noticeable by suddenly withdrawing the plug of wool and observing the change in the behavior of the leaves. This may easily be done by attaching to the wool a string or fine wire which extends beyond the mouth of the tube.

Explanation. This is one of the best proofs that the ions are particles mixed in with the gas, for the action of the wool in this experiment seems to be to filter or strain out these particles from the gas. The same experiment may be performed as a supplement to Experiment 13.

V. IONIZATION IN THE ELECTRIC ARC.

EXPERIMENT 17. Arrange an arc so that one carbon can be readily and quickly removed. This may be done by fastening the carbon in a clamp on a ring-stand. When the arc is in operation remove the incandescent carbon and place it quickly near the knob of a gold-leaf electroscope. The leaves collapse whether the charge is positive or negative. Now allow the carbon to cool to a red glow before bringing it near the electroscope. The negative leaves are discharged; the positive with difficulty or not at all.

Explanation. We have here a case of incandescent solids. See explanation of Experiment 8.

EXPERIMENT 18. Blow the gases, as in Experiment 11, from the arc or from its near vicinity toward the electroscope. The same results will be obtained as in Experiment 17. If the arc is blown out and the carbons allowed to cool slowly a time will be found when the gases will not readily discharge a positive charge, but after which the negatively charged leaves will readily collapse.

EXPERIMENT 19. Arrange an arc as shown in Fig. 7. *A* and *B* are the regular carbons; *C* is a spare electrode. *M* is an ammeter of sufficient capacity to measure the entire current flowing through the arc. Put the end of carbon *C* very close to the opening between *A* and *B*. A current of from one-twentieth of

Fig. 7.

an ampere, or less, up to the full current of the arc will be registered by the ammeter. This may be shown in a striking way by substituting for the ammeter an electric bell which indicates audibly the presence of the current. If now the carbon *C* is connected through the ammeter with the negative carbon, *B*, no appreciable current will be observed. This experiment is due to Fleming.[10]

Explanation. "The cathode is bombarded by . . . positive ions which maintains its temperature at such a high value that negative corpuscles (electrons) come out of the cathode; these, which carry by far the larger part of the arc discharge, bombard the anode and keep it at incandescence; they ionize also . . . the gas or vapor of the metal of which the anode is made, producing in this way the supply of positive ions which keep the cathode hot. It will be seen that the essential feature of the discharge is the hot cathode, as this has to supply the carriers of the greater part of the current in the arc; the anode has in general to be hot, otherwise it could not supply the positive ions which keep the cathode hot; in such a case as that of a third electrode put in the arc and acting as one of the anodes, we may regard the discharge as having two anodes and as one is sufficient to keep the cathode hot we can get the arc to pass to the other anode even although it is cold."[11] When *C* is connected to the cathode *B*, it is not hot enough to supply the requisite stream of negative ions.

NOTE.

In making the air-tight vessel of Experiment 13 a metal can about 8 centimeters (3.15 inches) high and 4 centimeters (1.57 inches) in diameter (a talcum-powder can will do) was taken and fitted with a three-hole rubber stopper. One hole of the stopper was about 1 centimeter (0.394 inch) in diameter; the other two were of ordinary size. A piece of glass tubing which would fit snugly into the large hole was cut off to a length somewhat greater than the thickness of the stopper. In one end of this tube was inserted a cork, through the middle of which had been thrust the rod for the extension knob of the electroscope. This rod was now fastened in a vise and melted sulphur poured into the tube until it flowed over the top. The cork was then removed and its space filled with sulphur, which was made to extend beyond the end of the tube. (This collar of sulphur at each end of the tube will help to keep the sulphur from working loose.)[12] This insulated rod was then inserted into the large hole in the stopper. (See Fig. 6.) The inlet and outlet tubes, *T* and *O*, were of ordinary glass tubing, about 4 millimeters inside diameter, fitting tightly in the other two holes. To insure tightness the tubes and the edge of the stopper were coated with vaseline.

At the last an ordinary cork with inlet and outlet tubes about twice the cross-section of the first was tried. This seemed to give promise of more rapid results if the cork could be made as air tight as the rubber stopper.

[9] J. J. Thomson and E. Rutherford, "Phil. Mag.," xlii, p. 392, 1896.

[10] Fleming, "Proc. Roy. Soc.," xlvii, p. 123, 1890.

[11] J. J. Thomson, "Cond. of Elec. through Gases," p. 613.

[12] I am indebted to Prof. Wm. Strieby of Colorado College, for suggestions regarding this method of insulation.

The Acme of Refinement in Mechanism.

THE London publisher Batsford has issued a richly illustrated volume of 800 pages, written by Mr. Britten and describing the marvelous creations of the old watchmakers. One of the most interesting of these timepieces was the exceedingly small repeater, striking eighth-hours which the celebrated watchmaker, John Arnold, presented in 1764 to George III, who subsequently recompensed the donor with a royal gift of 500 guineas. From the description of this watch which is printed in the *Annual Register* of 1764, it may be inferred that the watchmaker's gift was fully equivalent to that of the King. The diameter of the entire movement was 1/3 inch and that of the ruby cylinder (the first one ever employed) was 1/50 inch. The total weight of the movement, which comprised 120 parts, was 50¼ grains troy. The mainspring and its barrel weighed 4 grains and the dial weighed about the same. The weights of some of the smaller parts in grains were as follows: Large wheel and fusee, 2¾; striking spring and barrel, 1¾; striking wheel and pinion, ¾; fourth wheel of driving train, ¼; cylinder with its wheel and pinion, 1/16; balance wheel and pinion, 1/17; hairspring, 1/300. Imagine a hairspring weighing 1/300 grain! It certainly could not be made for less than twenty dollars, so that a pound of steel in this form would be worth more than forty million dollars.

It is said that the Emperor of Russia offered Arnold 1,000 guineas for a duplicate of this watch, but that the watchmaker refused the offer as he wished his masterpiece to remain unique.

M. Reverchon, who gives these details in a recent issue of *Cosmos*, adds that if Arnold could have visited the Paris Exposition of 1900 he would have seen modern watches even smaller than his own. The hairspring of one of these watches, made by Ditisheim at Chaux de Fonds, weighed only 1/600 grain, half the weight of Arnold's.

This shows that even in this age of machinery, there are artificers as skilful and adroit in handwork as the best of their predecessors. These artists, however, receive little encouragement from the wealthy amateurs and collectors who pay fabulous sums for antiques. A plaque of Limoges enamel was recently sold for $180,000, a fifteenth century Gobelin tapestry for $165,000, a painting by Raphael for $540,000. Still higher estimates of value are placed on pieces which are not in the market: Twelve hundred thousand dollars on the gold plate of the altar of St. Mark in Venice, $2,400,000 on the Sixtine Madonna in the Dresden gallery, $1,200,000 on Michael Angelo's Moses in Rome, $500,000 on the enameled gold salt cellar by Benvenuto Cellini in the Imperial Museum of Vienna. These estimates are given by the well-known German collector, Karl Marfels, who recently sold his collection of sixteenth and seventeenth century watches to Mr. Pierpont Morgan for nearly $400,000, the cheapest watch in the collection being valued at $7,500.

The great disparity between the values of old and news objects of art has naturally developed the manufacture of spurious antiques. This culpable industry has, at least, the merit of proving that the race of superfine artificers is not extinct, and it may possibly exert a beneficial influence on those experts and collectors who attach no value to objects of art which are less than a hundred years old, though it is to be feared that they will not readily f rsake a point of view which has become a fixed habit, and which still has the sanction of public opinion.

A New Method of Studying Gastric Secretions

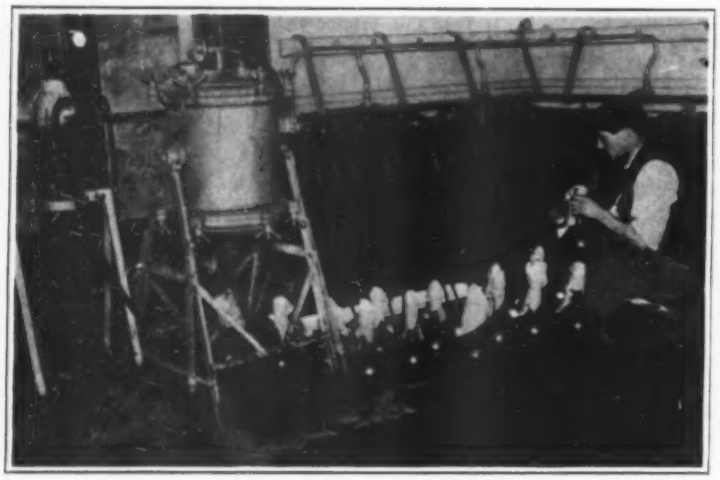
By the Paris Correspondent of the Scientific American

IT HAS been the opinion of many eminent medical authorities that we can obtain a much better substitute for pepsin by employing the natural gastric juice of a properly-chosen animal, providing that the proper sterilizing methods are used in order to preserve the liquid and allow it to be put up in bottled form for current use. This opinion seems to be borne out by the fact that the best pepsin preparations obtained in the ordinary way by mascerating portions of the stomach of the animal are found to contain but a small amount of various ferments which are of great value and may even be said to be essential for properly carrying out the digestive process. It is found by different experiments that the natural gastric secretion presents a great activity when compared with the usual pepsin preparations, so that there would be a decided advantage in employing it could it be properly extracted and bottled.

We wish to illustrate the method of carrying this out which is now used very successfully at Paris by Dr. Maurice Hepp, an eminent practitioner connected with the hospitals of that city. In order to bring his results to a practical stage he has in the first place made a great number of laboratory and clinical tests in order to compare the effects of pepsin preparations with those of the natural secretion. One point to be noticed is the selection of the proper animal which is to furnish the secretion. It is evident that an animal which feeds on a mixed diet is to be chosen rather than one which takes only one type of food, as do for example carniverous animals. The reason for preferring an omniverous animal is clear when we observe that its gastric secretion must contain the proper substances for assimilating all kinds of food. Since the food employed by man is of very varied character, we thus obtain a prepared natural secretion which is quite analogous to that of the human body. Were we to choose a carniverous animal, its secretion when administered to patients would be incompetent to deal with certain kinds of food, and the results would not be nearly as satisfactory. For this reason the pig is the animal chosen by Dr. Hepp, and it is interesting to note the detail of the various processes which he employs; firstly, for collecting the secretion without injury to the animal, and secondly, for sterilizing the product and putting it up in bottles for medical use.

The making of incisions in the digestive organs in order to place the collecting tube in position require considerable surgical skill so that the humanitarian and scientific requirements are fully met. Great care is needed in order to carry out the proper sterilizing precautions during the operation, as will be readily understood. The animal does not suffer to any extent, and indeed attention to this point is very necessary in order to prevent setting up any disturbances to the general system, which would exert a prejudicial effect on the digestive organs of the animal and thus influence the quality of the secretion. To carry out the operation the animal is placed in a suitable support holding it in an easy position, and the gastric secretion is thus readily collected by means of a long tube which runs into a collecting flask. In this way, Dr. Hepp obtains a crude liquid which he calls dyspeptine. The next step is to properly clear and sterilize it, and for this purpose he uses a set of porous diaphragms sterilizing filters of the Pasteur type which will be observed in another view. The liquid is contained in a large cylindrical vessel with hermetical closure, and is fed into the set of filters seen on the right under pressure of carbonic acid gas. The latter is furnished by a steel high pressure gas cylinder, using an expansion valve for regulating the pressure upon the liquid in the main tank. Each filter delivers the liquid by a rubber tube to one of the collecting flasks, whose mouths are carefully plugged with sterilized cotton.

Using these precautions Dr. Hepp finds that the product will keep almost indefinitely without showing any change, and this is of course an essential point for commercial value. As to the properties of the liquid, various authorities agree that they are superior to those of pepsin. It is to be noted that an ordinary chemical analysis is sufficient to give an exact account of the curative action of the liquid upon the human system. Aside from the peptonizing effect proper with which we are familiar, there is secured a certain stimulating effect which is now recognized to be peculiar to all glandular secretions. The present method furnishes a product which is very easily administered and is never found distasteful on the part of the patients using it. It is taken at meals, using two tablespoonfuls in a glass of lemonade or similar drink. Beneficial results are soon felt by patients suffering from various disorders due to deficiencies of the gastric juices, in which the normal acidity is diminished or even suppressed, as Van Noorden shows. The new product, which has been named dyspeptine, furnishes all the mineral and organic principles which are lacking, such as pepsin, zymases, acids, etc., which are indispensable for a good gastric secretion. It is well known that the synthesis of such liquids canot be effected by chemical means and this leads us to have recourse to the animal economy as our manufactory. The present method appears to be a decided step forward in this direction, and the best extracts prepared in the usual way by maceration do not give nearly as good results as the natural secretion obtained directly in this way. The previous observations of Messrs. Robin, Launois, Legendre, and other specialists, using natural secretion from different animals showed very clearly that such gastric secretions possess peculiar and specific recuperative and regenerative properties. Since then, Van Noorden and Mayer have used the present preparation made by Dr. Hepp and have found that it presents great superiority in the treatment of affections of the digestive tube and of nutrition. Laboratory work and clinical observations upon patients of the most varied types are very conclusive in this regard. We have a double effect of the liquid, due to the digestive action combined with a specific stimulating effect on the organs, so that it will overcome even some of the worst gastritic affections. It thus appears that the present preparation is likely to become a valuable agent in therapeutics.



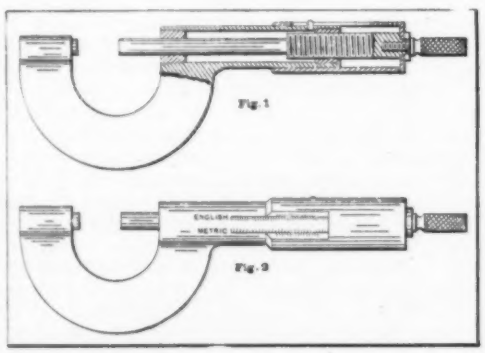
Filtering Under Pressure.

Bottling the Gastric Secretion.

Micrometer for Reading Directly the Various Systems of Measurement

MECHANICS have doubtless often realized the need of some precise measuring tool that would show various systems of measurement in their relation to each other, so that English measurement could be converted to metric, fractional parts to decimal parts, wire gages or rolling mill gages to parts of an inch or a millimeter, drill gage sizes to fractional or decimal parts of an inch or a millimeter, or, in brief, any desired system of measurement in proper relation to any other. Of course, the caliper square fulfills to a limited degree such a requirement, as some of these tools are so graduated that either English or metric measurements may be read directly. To make it possible to read various systems of measurement, the universal sliding micrometer shown in the engraving was designed.

This micrometer is designed along the principle of the ordinary micrometer in combination with a sliding caliper. It consist, as may be seen in the sectional view Fig. 1, of a body and barrel, a sleeve, and an operating screw. The action of the measuring bar is practically the same as with the ordinary micrometer, but the sleeve of this tool, instead of rotating, slides along the barrel, any rotary movement being prevented by a small pin which engages a longitudinal guide slot that is parallel to the axis of the screw. This sleeve has a concentric bore at its end, which fits a shoulder on the screw body, and it is held in place by a nut that is adjusted so as to permit a free rotation of the screw in the sleeve without any play. It will thus be seen that by operating the screw, a longitudinal motion is imparted to the sleeve. It is therefore immaterial what the pitch of the screw is, as in this case it serves simply to move the sleeve along with it. The position of the micrometer spindle with relation to the anvil, is determined by a scale on the barrel and a vernier scale on the sleeve, as illustrated in Fig. 2. Thus the barrel serves the same purpose as the beam of the caliper square and the sleeve acts as a vernier scale. It will be seen that this construction allows the micrometer to be designed for measuring according to a number of different systems, which are shown in their correct relation to one another. The zero mark, of course, coincides for each system of graduation on the micrometer, and the barrel can be made of any suitable diameter to permit the easy reading of the graduations.—*Machinery*.



Figs. 1 and 2. Universal Sliding Micrometer Which May Be Graduated With Various Systems of Measurement.

The Most Remarkable Tree in the Country

A Fine Example of Giant Vegetable Growth

AN illustration of the most wonderful tree in the United States is shown in Fig. 1. It is an enormous wild fig tree (*Ficus aurea*), growing in front of the barracks at Key West, Florida. This species is native to extreme southern Florida and adjacent keys, and is one of the survivors of the severe hurricane which swept the lower part of the State last October. All species of the genus *Ficus* are generally known as rubber trees, but the English speaking people of Key West call this tree "The Banyan," since it has the characteristics of the East Indian banyan (*Ficus indica*). It is the only tree of this species on the key, and visitors to Key West are always taken to see this wonderful specimen. It has been estimated that it is a little over 200 years since the seed was dropped by a bird into the crown of a cabbage palmetto, where it germinated and passed through its earliest development, but subsequently became connected with the ground by the root. The trunk is now more than 40 feet in circumference, and although the crown is not so large as might be expected from the size of the trunk, it forms an exceedingly dense canopy of evergreen leaves through which the sun never penetrates.

The so-called banyan tree in Key West has not been well cared for during the last five years, and at present it does not appear to be at its best. No new columnar props or trunks, as they are called, have recently been developed in order to support the branches, and the repeated hurricanes have done considerable injury to this famous tree. Other specimens of *Ficus aurea* are found on most of the keys and on the west coast of the mainland as far north as Tampa, where they are very common, and though some representatives of the species almost equal in size the famous Key West tree, none are quite as noble looking.

The only other species of this genus native to Florida is the poplar-leaf fig (*Ficus populnea*). This is a comparatively rare tree and is found only on several keys from the Bay of Biscayne to Key West and on the west coast as far north as Ft. Meyers, where one of the largest trees of this species now stands. This specimen, which is illustrated in Fig. 2, is in front of the Royal Palm Hotel, in Ft. Meyers, and everyone who visits this place is attracted by this interesting tree, which is fortunate in having escaped mutilation by wind and storm. It has lost no large limbs during the recent hurricane, shows no dead or drying wood, and is in vigorous health.

Altogether these two specimens shown here are fine examples of what the two species of wild fig trees in Florida may develop into under favorable conditions and what interest will be attached to them if they receive the care they deserve. Some of the Florida nurserymen are propagating and selling cuttings of these two species. This method of propagation is much quicker and easier than from seed, and if the young stools are planted during the rainy season they will strike root very soon after planting and produce a growth far more rapidly than that of the tree known to the botanist as *Ficus elastica*, the common stove plant, or rubber tree.

Fig. 2.—A Large Poplar Leaf Fig Tree in Front of the Royal Palm Hotel, Ft. Meyers, Florida.

Some Historic Conflagrations

FIRE, as well as war and diplomacy, has played its part in writing in destruction and construction of the history of the world; for while the immediate result of fire is destruction, the final effect is sometimes construction, bigger, better and more enduring edifices arising on the site of the ruins. Nobody can deny, says *Building Progress*, that the Chicago fire was the turning point for its greatness, and that without the fire Chicago would not be the Chicago of to-day. New York, Boston, San Francisco and Baltimore likewise have been benefited by destructive fires, and the best calamity that could happen old Philadelphia would be the complete destruction of the business section, provided it brought with it no loss of human life.

Fire, then, is constructive when it roots out the old wooden rookeries which bar the way to beautifying and improving a city, and, while generally a conflagration is destructive only, we must give it credit for the little good it sometimes accomplishes.

But most great fires of history were destructive more than constructive, and the loss of life in some of them was appalling.

In the first fire of Moscow—for that city had to suffer twice from the same scourge before they learned their lesson—there were over 200,000 victims. Consider for a moment what that means. One fire in one city at the early date of 1570, when cities were not anywhere nearly so large as they are to-day, snuffed out as many lives as there were people in Minneapolis in 1900, or almost half as many as there are in the whole State of Rhode Island at the present time.

The Moscow authorities profited by the lesson of the first fire sufficiently to provide means for escape in case the conflagration was repeated, but they failed to grasp the idea that if the buildings were made fire-proof both lives and property would be safe. The result was that in 1812 they were visited by another destructive fire, which destroyed 15,500 buildings, but not enough lives to make it worth recording in a country where life is held so cheap. No doubt there were some fatalities, for a fire covering such a large area could not rage without the probability of some victims.

London was the second city of the world to suffer a great fire loss. In 1666, over a century before the Declaration of Independence was signed, the city was swept by flames, destroying 13,200 houses.

Following closely on the second fire of Moscow a disastrous conflagration raged at Cairo, resulting in the deaths of over 4,000 people. That was in the year 1824 and was just six years before the great fire of Constantinople, which destroyed block after block of buildings, amounting in all to 18,000 houses.

Large historic fires have followed in rapid succession since the second Moscow fire. The dates and the loss suffered are here presented in tabular form to show at a glance the price we pay to fire, which when under control becomes our servant, but uncontrolled our master and scourge:

NOTABLE HISTORIC FIRES.

YEAR	PLACE	LOSS
1570	Moscow	200,000 victims
1666	London	13,200 houses
1812	Moscow	15,500 houses
1824	Cairo	4,000 victims
1831	Constantinople	18,000 houses
1835	New York	$30,000,000
1842	Hamburg	$36,200,000
1851	San Francisco	2,500 blocks
1871	Chicago	$165,000,000
1872	Boston	$75,000,000

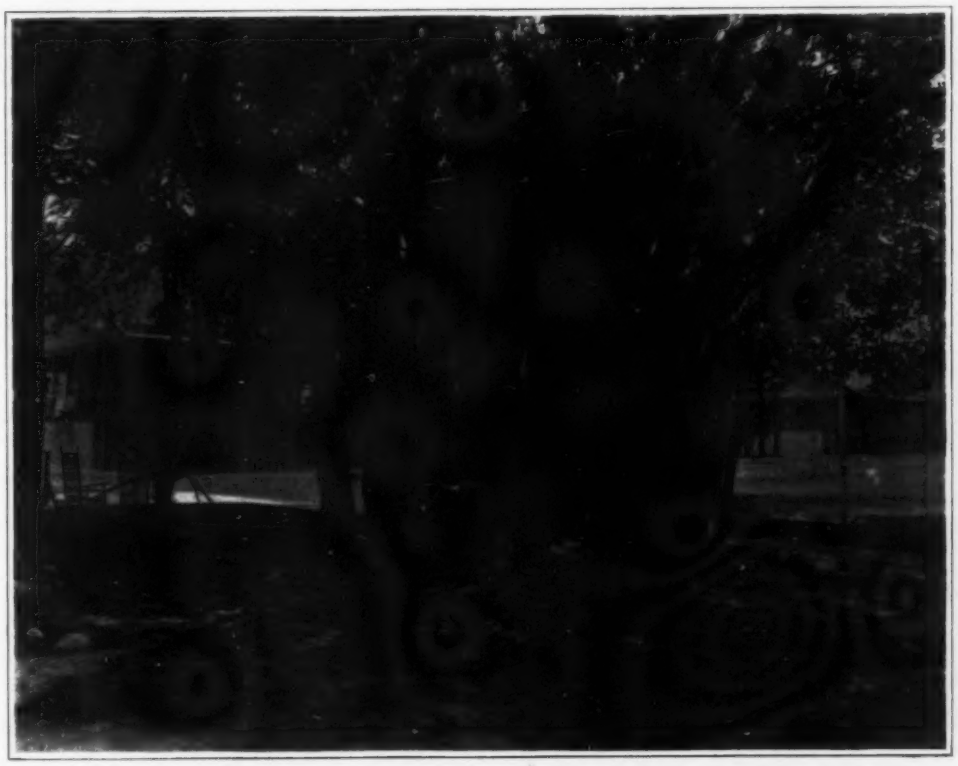


Fig. 1.—The Largest Wild Fig Tree (*Ficus aurea*) in the United States.

TWO REMARKABLE TREES.

Deterioration of Macadam Roads and the Probable Cure*

Problems That Arise From The Increased Automobile Traffic

By Samuel D. Foster†

UNDER the name of macadam roads, I expect to class both the road designed by Telford and the road designed by MacAdam.

The Telford road consisted of placing upon the level bed prepared for road materials, a bottom course or layer of stone to be set by hand, in the form of a close, firm pavement, the thickness of this foundation course varying from 5 inches upward, depending upon the material composing the subgrade and the vehicular traffic it will be called upon to carry. Upon the top of this foundation is placed a course, or courses, of varying sized stone, to form what is known as the "metal surface."

The MacAdam road differed from that of Telford in that MacAdam was satisfied with laying the metal surface directly on the surface of the ground after the irregularities had been leveled, the side ditches formed, and the proper drainage system installed. This metal surface was composed of hard stone broken to a uniform size and cubical in form, ranging from 1½ to 2 inches, and was placed to a depth varying from 5 to 9 inches.

As to the relative merits of the two roads, I will not go into detail, but will state that in Allegheny County the greater percentage of our roads have been constructed from a combination design taking the best of the Telford and MacAdam ideas.

Our roadways are graded to a width of 30 feet. In the center of this 30 feet the subgrade is formed for a width of 16 feet, having a crown of four inches. Upon this subgrade is placed a Telford foundation eight inches in depth, throughout the full width. This foundation is thoroughly rolled by a 10-ton roller, and the larger voids filled with small stones. This rolling continues until a true and uniform surface is obtained for the foundation.

Upon this foundation is placed approximately five inches of loose broken stone, either limestone or trap rock, of a size that they will pass through a three inch ring and not pass through a 1½ inch ring. This stone is thoroughly rolled with a roller weighing not less than ten tons, and the depressions filled and raked until the surface is true and even. Upon this sufficient dust or screenings of some cementacious stone is laid as a binding course.

This course is just sufficient to bond the stone and render the surface smooth. The binding course is then thoroughly sprinkled and rolled with a 10-ton roller until the passage of the roller causes no waves in the surface. This binding of the surface stones constitutes the essential feature, to my mind, in any metal road; and in what may be termed the life of the macadam road.

Upon this surface now must come the traffic, the impact, the drag, and the wear of all horses' hoofs, wheels and runners of vehicles passing over it. The impact of a horse's hoof upon the macadam road has a tendency to spawl or crush the stone used in the wearing surface. The wheels of the wagons where the load is greater per square inch than any particular stone is able to bear, will cause the beginning of a rut, and the sliding of the wheel from one stone to another will grind more or less dust from the metal surface. The automobile, driven by powerful engines, exerts a force in the rear wheels which causes what we may term a continual slide or scraping. This scraping has the effect of pulling the fine particles of binding material from between the stone and in many cases of loosening the stones themselves and starting what is known as raveling of the roadway. These stones, drawn from the roadway, are quickly pulverized by passing wheels; and the body of the automobile, constructed as it is, passing at great speed over the road, causes a vacuum or heavy draft immediately under the car, which sucks this dust up from the roadway and the wind blows it into the fields. Inasmuch as this dust constitutes the life of the road, it is a simple matter to figure from the amount, and the kind of traffic over roadways, the life of the macadam road in each particular locality.

While in a great measure we may lay the blame of the deterioration of macadam roads to the automobile, it may be well to remember one point in particular, that it is not so much the automobile itself that is the cause of the deterioration of our roadways, as it is the fact that where one man fifteen years ago would own a pair of horses for pleasure, ten men to-day own automobiles; where a family several years ago having a team and carriage would use that vehicle for pleasure driving probably once or twice a week, fifteen out of twenty automobile owners today use their vehicles twenty days out of every month during what we might term the season of good roads. So it is not altogether the automobile as much as it is the increase in traffic over our roads that is the cause of this deterioration to such a great extent of what it was a few years ago.

Experiments with a view of allaying this dust nuisance were first carried on in California, and the first asphalt oil used was about the year 1896. In 1898 about six miles were oiled in Los Angeles County, California, with the idea of laying the dust; the experiment was such a decided success that the idea spread rapidly and many miles were soon covered with asphaltic oil. It was then found that the oil not only laid the dust but also bound the dust particles together and formed a tough layer of an asphaltic nature, that acted as a real road preservative. From these simple experiments in California, the idea that there was a chance of preventing deterioration on macadam roads spread all over the country and the many highway engineers who were interested in their work began the investigation of methods for the prevention of this deterioration.

Naturally this investigation was along the line of saving the roads already built, and in the main consisted of applications to, and treatments of, the surface alone. Oils of various grades and containing different amounts of asphalt were soon on the market. The first of these were the natural asphaltic oils of the Texas, California and Kentucky districts, which have a more, or less, asphaltic base, but at the present time almost all the oil companies have residuum products that are for the most part the study of their chemists and experts. The use of tar as a road preservative dates back to about the year 1886, when it was used in the city of Melbourne, Australia, with a great deal of success. It seemed to bond the road together thus both laying the dust and preventing deterioration. These experiments were continued in several countries, France, England and the United States leading.

At present these road preservatives may be roughly classed under the following heads: Residuum-asphalts, or asphalts obtained from crude oils, Natural asphalts such as Bermudez, Cuba and Trinidad and the tar products.

Experiments have also been carried on with a material named by its inventors "Glutrin," and is made from the residuum of the wood pulp of the spruce tree. It has a tendency to thoroughly bind together the particles of the road and render the surface of the roadway waterproof.

The writer's first experience with oil for use on roads was in 1907, on the Isthmus of Panama, where it was used to lay the dust on the roadways leading through the hospital grounds at Ancon. The oil used was the natural California oil and had a rather heavy asphaltic base. We were successful in what we attempted to do and had little or no complaints from dust thereafter. I have followed very closely the use of oils since that time and have had more or less success in the application of oils for both the laying of dust and the preservation of the roadway. At first, the application of the lighter oils, or what may be termed the road preservatives, looked like a solution of this very vexing problem; and perhaps is for roads over which the auto travel is predominating, as the tendency of the automobile is to iron out the road and keep it smooth. Where this is so the road readily sheds the rainfall and affords very little chance for the frost to do much damage; but, where a roadway is subjected to a very heavy wagon traffic, the horses' hoofs constantly cut into the soft asphaltic surface and the rain has easy access and forms a muddy condition that holds the water and causes a puddle that eventually breaks the bond between the small surface stones and causes the road to start to ravel. Then again the lighter oils in these asphaltic surface treatments penetrate the road, and in many cases entirely surround the small surface stone with an oily film and in so doing bring about a condition that prevents the road being rebonded and the stones coming loose are quickly crushed into dust.

The experiments carried on in this country have been many and varied; the first were, as stated before, for the purpose of laying the dust which had become such a great nuisance; the idea that the oil had another value that held out a vision of road preservation caused a number of experiments along the line of increasing this value, and I believe Allegheny County has had as much success along this line as probably any other country. Our method consists today of the application of an asphaltic oil running about 50 per cent asphaltic base. This oil comes in tank cars and the oil is fluid enough to be readily pumped from the cars, in ordinary summer weather, but during the first few days of each season it has been necessary to apply steam heat to the cars to cause it to flow readily. This oil is pumped into tank-wagons, that hold from 400 to 500 gallons and are provided with a valve and distributor arrangement that allows the operator to govern the amount of flow at all times. The roadway before being treated is swept thoroughly by a horse sweeper and with hand brooms to entirely remove all dust and dirt from the surface. This also loosens the immediate surface and gives the oil a chance to penetrate the road and form a bond. The road is then left to dry by the natural evaporation of the lighter oils, or is covered with small stone or sand, to alleviate the disagreeable condition that sometimes follows the application of this light oil. The work done during the past three years has shown up extremely well and we have cases where the oil has stood an extra heavy travel for a period as high as two years without showing a dusty condition, and this is on such roads as the Brownsville and Steubenville Pikes.

The cost of applying this light oil for the various years since 1907 is as follows:

	1907 Per sq. yd.	1909 Per sq. yd.	1910 Per sq. yd.
Oil material		0.01599	0.012212
Labor	0.0615	0.00663	0.007086
Demurrage and frt. chgs.		0.00018	0.000315
Supplies, tools, wagons, etc.			0.001265
Averages	0.0615	0.02280	0.020878

The heavy cost during 1907 was probably due to the fact that the work was done by contract. During the years 1909 and 1910, the work was carried on by our own maintenance force, and correct cost data has been obtained.

On the Steubenville Pike, outside the city limits west, granulated calcium chloride was used to allay the dust. Calcium chloride is a chemical salt, white, clean and non-corrosive and is without odor. Its main property when applied to a road is that it immediately absorbs moisture from the atmosphere and holds that moisture in the road, thus keeping the road moist and dustless, and by preventing dust lengthens the life of the surface. It is distributed on the road either by hand or by machine distributor, and costs approximately between three and four cents per square yard during the season. It is necessary to treat a roadway with calcium chloride every four or six weeks, dependent a great deal on the humidity of the air. The main point of merit in this treatment lies in that the disagreeable conditions arising from the first applications of oil are not present where calcium chloride is used; on roadways in close proximity to a number of houses and where there is much travel of a pedestrian nature it might well be recommended. Another point in favor of this material which I have gathered from our experiments is that ice and snow do not remain as long on the roadway and in this way helps to solve the question of slipperiness in wintry weather. These experiments looking towards the prevention of deterioration have been carried on by most engineers with the idea in view of merely tiding over the immense systems of macadam roads already built, until a more satisfactory surface could be obtained. As it was evident from the start that any application of this nature would not bring about a permanent result, practically all the state highway departments and the large corporations and several universities have been carrying on experiments either along their own lines or under partial supervision from the Department of Public Roads of the United States Government, with the idea in view of obtaining a pavement that would withstand the great tractive force of the automobile and still present a surface that would not be injurious to horse travel.

It will not be attempted in this paper to go into the relative merits of brick, or block, construction and the macadam roads, as this paper deals entirely with the macadam road. It was at first though by engineers that the macadam road was done for, and that a new type of road would have to be studied out, but as experiments went along, it was found that the principle of the old macadam road was right and that a first-

* Proceedings Engineers' Society, Western Pennsylvania.

† County Road Engineer, Allegheny County, Pittsburgh, Pa.

class surface could still be constructed under the old general macadam idea and that the fault and cause of deterioration lay in the binding material.

These binders consist of asphalt materials, natural asphalts, Gilsonite products, coal-tar products, and portland cement, and the surface treatment, by penetration method or by the mixing process. The general manner in which the penetration method is carried on is to put down macadam in the ordinary way up to the point of beginning of binding, which had been previously done by water and stone chips. The binder then sprinkled upon the roadway either by hand or by machine distributor. This method has been varied in several ways, as for instance, larger stone have been placed on top and the smaller stone on the bottom of the surface course. The bitumen has been applied to the stone and a layer of sand placed over the bitumen; another where the stone were put on in two courses and the bitumen applied to the surface of the first course and surface of second course. The amount of bitumen varies from ¾ gallon to as much as five gallons per square yard. The use of five gallons, however, was a rare instance. The cost ran from 48 cents to $1.25 per square yard.

The mixing method may be classed in two types, that of the pavement where the aggregate is carefully graded and the least possible percentage of voids is present, and the type for less heavily traveled roads in which the aggregate is not graded and has a large percentage of voids. In the first type, the materials are broken stone, and sand of graded sizes, mixed so as to form a dense mixture. This aggregate is heated and thoroughly dried and dumped into a mixer in approximately exact proportions, the amount of bituminous material being that necessary to make a mixture of the highest density. These materials are thoroughly mixed in machines, of which there are various types, and placed on the roadway while hot. The results secured by the use of this pavement may be classified with the results obtained from brick or block pavements as to durability, but they have in a few instances proven rather hard and slippery surfaces. This may be obviated by the application of a rough sealing coat.

In the second type, the stones are thoroughly dried, being what is termed "run of the crusher" grade of stone. With this stone are mixed sufficient sand to fill the greater percentage of voids and enough bituminous material to thoroughly permeate the whole mixture. These materials mixed under the second type have been laid both warm and cold and very satisfactory results have been obtained from both.

Another method of surface construction is the penetration method, using portland cement as a binder. The stone is placed on the road to a depth of approximately eight inches and thoroughly rolled with a 10-ton roller, until a true and uniform surface is obtained. Upon this is distributed cement grout of a one-part cement and two-parts sand mixture, and the road again rolled, and allowed to set. This form of roadway has been successful in some parts of the country. The writer had some considerable experience and a great deal of success in the mixing of a concrete pavement of a one part cement, 2½ part sand and five part traprock in Panama City. On this pavement, the mixture was made and placed in the street to a depth of from four to six inches, thoroughly rammed and brought to a uniform surface by means of a templet. The uniformity of temperature, however, in Panama may have been in a measure responsible for the success of this pavement. In a northern climate where the contraction and expansion of concrete must be taken into consideration, it is very doubtful if this form of pavement would be practical.

The experiments in Allegheny County have been carried on along practically the same lines as in general throughout the country. On the Steubenville Pike a bitumen pavement was constructed in which the stones were supposed to be graded very carefully and mixed with a heavy bitulithic binder. The stones were graded, thoroughly dried, and conveyed into a large roadway mixer, mixing a batch of approximately 2,500 pounds at a time. To every ton of stone were added 130 pounds of bitulithic binder. This material was carried immediately from the mixer and placed in the road by small hand-barrows. It was raked into a true and uniform surface, rolled with a 10-ton roller, and allowed to thoroughly set before travel was allowed to go on the road. This road at the present time does not show any cracks, and gives promise of making an exceptionally good roadway. The one objection seems to be in the nature of a slippery surface; but it is my opinion that as soon as sufficient wear has been placed on the road to cause the stone aggregate to be exposed that this condition will be much improved. The cost for this type of pavement will approximate between 80 cents and 90 cents per square yard, according to the location of the roadway.

On the Freeport Road a type of the second class was constructed in which traprock of size, 1½ inch to dust, "run of the crusher," was thoroughly dried and mixed with asphaltic binder, about 110 pounds of asphaltic binder being used to one ton of stone, together with two bushels of sand. A precaution on this work was used by cleansing the stone thoroughly with naphtha before placing the asphalt. This material was placed in the road both warm and cold and like results obtained from both experiments. This material at the present time shows a very satisfactory surface, and gives promise of withstanding the extra heavy wear of the traffic placed upon it. The detailed costs of this type of pavement are as follows:

Amiesite material, cost per square yard.....	66.25c.
Labor cost per square yard, including rolling.	10.17c.
Total cost of placing same on road, per sq. yd.	76.42c.

On the Lincoln Way Road, just outside the city of McKeesport, a mixture of granulated slag and asphalt tar binder was used. This material was composed of slag screenings ½ inch and under, fine slag dust, asphalt tar binder, and an asphalt residuum oil. Twelve per cent in weight of slag was mixed with 7 per cent, in weight of slag, of the asphalt tar binder, at a temperature of 300 degrees. The ½ inch slag screenings were mixed with two per cent, in weight of slag, of the residuum oil at 300 degrees. The two mixtures are then combined and thoroughly mixed, and must be placed on the road while hot. This experiment shows a very satisfactory condition at the present time, and seems to turn the rainfall quicker than any of the other experimental work, and gives promise of being able to withstand extra heavy traffic. The costs of this experiment, as near as possible to obtain, are as follows:

A mixture of one ton of material cost $3.02. The cost of the oil was 60 cents and the cost of labor in mixing, 60 cents, making a total of $4.22. We are able to obtain approximately 10 square yards to the ton, making a total cost per square yard of 42 cents. To this add the cost of placing and rolling of 10 cents per square yard, bringing the actual cost to 52 cents per square yard. This is by far the cheapest and if it holds up anyway well at all, will make an economical and serviceable pavement.

On the Perrysville Road the penetration method was tested by placing four inches of limestone ballast, thoroughly rolling the same, and applying by hand sprinklers a coal-tar binder to the amount of 3.8 gallons per square yard. Unfortunately, this work was done very late in the fall, and the binder became chilled on striking the cold stones on the roadway and a sufficient penetration was not obtained. Consequently, about twice the amount of binder necessary was present in the upper two inches of stone and none penetrated to the base. When the warm suns of last summer and very hot days came, very naturally the excess of binder was drawn to the surface and ran into the gutters and made a very disagreeable condition. This was obviated by distributing 1½ to 2 inches more crushed stone over the road and thoroughly rolling the same. This apparently cured the defect. The cost upon this type of road is as follows:

Tarvia material, cost per square yard.....	24.5c.
Stone material, cost per square yard	45.6c.
Labor charges per square yard	9.4c.
Total cost per square yard	79.5c.

On our Peoples Road an experiment was made with Kentucky rock asphalt. This material is a disintegrated sandstone, thoroughly impregnated with natural mineral asphalt to a percentage of approximately eight to ten per cent. The foundation course of two to three inches of ballast is placed on the road and thoroughly rolled. On top of this one inch of rock asphalt is distributed and thoroughly rolled into the surface. The surface is then raked over with an ordinary rake in order to roughen up the asphalt binder. Another inch or inch and a half of rock asphalt is then distributed over the surface and the road again rolled until thoroughly compacted. This surface presents a rather rough appearance for six weeks or so after construction, inasmuch as this material contains some light volatile oils and does not obtain its initial set until these oils are evaporated. After it has been thoroughly exposed from four to six weeks it presents the appearance of a sheet asphalt pavement, and for some districts where the traffic does not include extra heavy hauling, and for level roadways, this type of surface—with some improvements which we expect to experiment with this coming summer—it is believed will make a cheap and economical road. The cost of this type of road is as follows:

Rock asphalt material, cost per square yard, f.o.b. cars	36.6c.
Crushed stone on road, cost per square yard....	18.4c.
Labor cost per square yard (including hauling asphalt)	21.1c.
Total cost per square yard	76.1c.

This constitutes a résumé of our experimental work in Allegheny County.

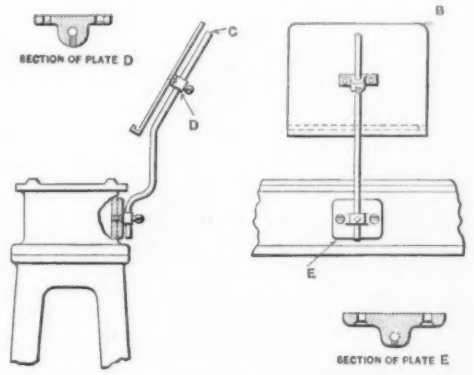
New Determination of the Moon's Distance

By A. C. D. CROMMELIN, D.Sc., B.A.

DURING the last six years the small bright crater Mösting A has been regularly observed on the meridian both at Greenwich and the Cape. It is much easier to bisect the crater with a micrometer wire than to place it tangential to the moon's limb, which is often serrated by mountains. About a hundred nights are available on which the crater was observed at both stations, and comparison of these has given a new determination of the moon's distance. The chief source of uncertainty in the result is the fact that the shape of the earth is not yet known with great precision. The distance was accordingly computed on two assumptions of the shape, viz., compression 1/293½ and 1/300; these about cover the present uncertainty. On the first assumption Hansen's parallax (which is 57 minutes 2.23 seconds) needs a correction of plus 0.50 seconds, and on the second of plus 0.12 seconds. On the former assumption the moon's distance comes out 238,817 miles. Another way of finding the distance is based on the observed period and the force of gravity at the earth's surface. This method also gives results that vary, though to a less extent, with the earth's figure. The deduced corrections to Hansen's parallax are 0.45 seconds and 0.36 seconds on the above assumptions. Hence to make the two methods agree we must take the compression as 1/294½. This applies to the mean meridian of Greenwich and the Cape, for it is quite possible that it is sensibly different for different meridians. Sir David Gill has for many years been endeavoring to have South Africa geodetically connected with Europe, and only a few links are now needed to complete this great work, which would give a measured meridian extending from the North Cape to South Africa, and would give the compression of this meridian very accurately. It seems that it would be advisable for equatorial observatories to measure the moon's distance by the diurnal method (comparing observations made east and west of the meridian at the same station). The equatorial parallax of the moon would thus be given, free from uncertainty arising from the figure of the earth, and it would in addition be possible to test whether the equator has any ellipticity by comparing the results obtained at different equatorial stations. The measures might be made photographically, for Prof. Pickering and Mr. H. N. Russell have lately shown that good photographs of the moon for position can be obtained by giving the surrounding stars a time exposure, the moon being screened by a disk except for a fraction of a second, the time of which may be automatically recorded. This plan is analogous to that used for many years at Greenwich for photographing Neptune and its satellite, and double stars that differ much in brightness.—*Knowledge.*

Lathe Bracket for Blue-Prints

THE bracket shown in the illustration is very simple and will keep blue-prints or working drawings constantly before the mechanic. It is made of two cast-iron plates *D* and *E*, rod-arm *C*, bent at any desired angle, and sheet iron holder *B*. The size of screws should be determined by the size of bracket



Blue-Print Holder Attached to Lathe.

made. As the reader will notice, there are no breakable parts, and very few loose ones. I would suggest that the surface on the arm *C*, which comes in contact with the set-screws, be filed or milled flat; this will keep the bracket from turning. By using a bracket of this description, the percentage of mistakes made will be greatly reduced and more accurate work done.

L. H. GEORGER.

Buffalo, N. Y.

Electrical Notes

The Pay of German Telephone Operators.—Telephone "girls" in Germany cannot work after the age of seventy, though they can retire on pension prior to that advanced age. Positions are obtained by civil service examination. The average age on entering the business is said to be in the neighborhood of thirty years, and many remain for life. Discharges cannot be effected without considerable red tape. When an operator has worked up to $450 a year and $150 extra for house rent, she stays at that pay until pensioned. —*Electrical Review.*

Commercial Loss From New Inventions.—There is a gloomy side to every question, and some people seem to have a remarkable propensity for discovering it. We read in the *Electrical World* that at the semi-annual meeting of the National Electrical Supply Jobbers' Convention one of the subjects discussed was "The Loss Entailed on the Electrical Trade by the Activity of Inventors." It was stated that great losses are sustained by the depreciation in value of goods which, though up to date when purchased, are supplanted by other inventions.

Electric Furnace Design.—The engineering skill required in the design and construction of electric furnaces lies not in the fundamental conversion of energy, but in building them well and efficiently, the latter being of far greater importance than in combustion furnaces in which the cost of a unit of heat is so much less that great economy is not of so much importance. Heat generated electrically costs more per unit of heat, hence successfully to compete with combustion heat it must have other advantages; one of these is that such heat can be applied more directly to the materials, hence with far less waste, and when in addition the furnace is built so as to keep the heat in it as much as possible, the difference in the amount of heat required may become very great, thereby compensating for the higher cost per unit.

Alternating Current Potentiometer Test.—In an article which recently appeared in the *Electrician*, Mr. H. Tinsley describes some tests on a Drysdale alternate-current potentiometer to ascertain the accuracy of the instrument. He arranged a circuit containing capacity and non-inductive and inductive resistances all in series, which was fed by alternate current from a small transformer. The voltages across the various components of the circuit were measured on the potentiometer, and the corresponding phase-angles were read off on the dial of the phase-shifting transformer. Knowing the value of the current in the circuit—which was kept constant—it was then possible to calculate the resistances, reactances, etc., of the various parts of the circuit. The voltages and angles were then plotted as vectors. The triangles so obtained were practically perfect in nearly all cases.

The Electrical Energy Required for the Maintenance of One Light Unit.—We read in *Cosmos* that MM. H. Buisson and Ch. Fabry have determined for light of different wave lengths the number of watts radiated per mean spherical candle-power. They have thus found for violet light 0.31 watt, for green light 0.018, and for yellow light 0.021 watt. The green rays represent the portion of the spectrum for which our eye is most sensitive. The figure found for this radiation, 0.018 watt candle-power, therefore correspond to the minimum expenditure of energy for a given light effect. The luminous intensity in this portion of the spectrum is 55 candles per watt. The number of watts per candle-power is slightly greater for yellow light than for green. However, the yellow rays enter very largely into the light emitted from mercury vapor lamps. As regards violet radiation, this is sent out in quite high proportion by the mercury lamp, but is of very little consequence for illuminating purposes, owing to the low sensibility of our eye for rays of such short wave length.

The Coherer as a Storm Indicator.—Approaching storms are indicated in the new instruments used by Prof. Turpain of the University of Poitiers. He employs a coherer and an aerial somewhat similar to those used for wireless telegraphy. The coherer is actuated whenever electric discharges occur in the air owing to storms, and an instrument is thus operated which records the indications on a revolving drum. Prof Turpain finds it best to use a coherer made of two crossed sewing needles, as it works better than a filings coherer. Such an instrument can be made in a very compact form and is of much service in smaller meteorological stations. An aneroid barometer can be made to record on the same drum so as to show the storm record along with the barometric pressure. He states that he can observe an approaching storm as much as four hours before it arrives. A more sensitive instrument is a bolometer made up of a very fine platinum wire contained in a Dewar double-walled and silvered vessel. The variations of current are recorded by a galvanometer with swinging mirror and a registering photographic band.

Engineering Notes.

A Lathe Kink.—Occasionally a machinist gets a casting to turn that is too large for his lathe, or the overhang from the chuck or faceplate is too great, causing a great deal of chattering. Tightening the boxes and stiffening the tool support are usually not sufficient to eliminate it. According to a writer in the *American Machinist*, a good method of getting over the difficulty is to run the lathe on the reverse belt, and turn the tool upside down. This prevents the casting from jumping and riding on the tool. It has also been found that a heavier cut may be taken through a rough hole or one that was out of true, thereby getting under the skin of the casting quicker and saving the tool.

Copper for Water Pipes.—The question of the use of copper water pipes in private houses was raised at a recent meeting of the health board of the Seine department. A plumber had written to the Prefect to ask if copper piping could be used. The Director of the Municipal Laboratory said that no regulation existed prohibiting such a practice, but he advised the Prefect to consult the board of health. M. Armand Gautier was appointed by the board to study the matter, and he has reported in favor of permitting the practice. Lead, said M. Gautier, was used because it was cheaper and more pliable than copper, but he saw no objection to the use of the latter.—*The Engineer.*

Distortion in Ships Furnaces.—It is a well-known and established fact that many cases of furnace distortion in foreign-going steamers have happened after from forty to seventy days' steaming, while lying under heavy banked fires just before going to discharging berths. The period of danger, therefore, appears to be when lying with steam on boilers and engines at rest. It would seem that making steam without taking it away by the engines is far more dangerous to the furnaces than when making steam to the utmost and engines taking it away. This seems paradoxical, but, according to Mr. J. Innes, it is one of the causes of tramp steamer furnaces being distorted. During the time of banked fires it would also appear that the deleterious matter held in suspension through the excited state of the water sinks, and a portion naturally falls on the furnaces, and may possibly have something to do with the creeping down of furnaces, which is so very common.

Keeping Records of Ties.—The Lehigh Valley Railroad Company has adopted a plan for recording the age of every new crosstie on the system. This will enable the company to determine with mathematical accuracy the relative efficiency of the different woods and the value of the creosote preservation treatment. It is done in this way. First, the dating nails are manufactured with the proper numerals on the heads, indicating the year. For example, "11" means the year 1911. Then one of the nails is driven into each new tie as it is laid on the track. Thus in the future the maintenance of way experts will be able upon the replacement of a tie to know just how long it has lasted. The steadily rising price of lumber compels the railroads to use wood that has undergone "treatment" to prevent decay. It is expected that the injection of creosote oil into the pieces of the wood will double its life.

Leather as a Constituent for Road Pavement—(An Interesting Experiment Carried Out at Handsworth, England.) Some rather remarkable experiments have just been made at Handsworth, a suburb of Birmingham, England, with a view to testing the qualities of scrap leather as a constituent in road surfaces. The patch of ground selected for the test is subjected to heavy wear by the passage of fire engines, water carts, and other vehicles. The pavement has been in place now for over fifteen months, yet shows practically no signs of wear; in striking contrast with other portions not treated by the new method. The process is described as follows: Bitumen, pitch, asphalt, tar, oil, or the like is heated to a suitable consistency, and scrap leather is then added. This scrap may be used just as it comes, in very large pieces or it may first be cut down to smaller pieces or shredded or reduced to pulp. The best size of material to use depends to some extent on the nature of the traffic which is to pass over the road bed. For streets where the traffic is heavy, larger pieces of leather, may with advantage be used; for foot paths and lighter roads, the leather is preferably cut in small pieces. After the composition has been prepared in the manner indicated, it is spread upon the ground, adding at the same time stone, gravel, granite, or similar material. The surface, when set, gives excellent wear, raises little or no dust, and is very resilient and very silent. It gives a good grip for horses and is in every way superior to rubber, with which one would naturally compare it. The cost of the new road material is stated by the inventors to be about 54 cents per square yard, but this will of course vary in different localities according to the supply and demand for leather waste.

Science Notes.

Economizing Oats.—In a note published in *Cosmos*, and credited to the *Journal de la Sante*, it is recommended to soak oats in water for some time before feeding them to horses. Experience shows that by this means, rations may be reduced by one-third. Horses, especially when their teeth are worn, chew oats very imperfectly; others devour them so greedily that the greater part escapes mastication, and hence digestion. Maceration in water makes up for the deficiency. The grains swell, are softened, and are readily crushed by the teeth, and digested by the horses.

European School Statistics.—Consul General T. St. John Gaffney reports that there are 465,451 schools with 45,500,000 pupils in Europe, presided over by 1,119,413 teachers. According to the average, there is 1 teacher to every 45 scholars. Twelve years ago there was only 1 teacher for every 60 scholars. The number of teachers in Russia is about 195,000, while those in Germany number 168,000. In Russia there is 1 teacher to every 644 inhabitants, and in Germany there is 1 teacher to 361. In England there are 177,500 teachers occupied, which allows 1 teacher to every 234 inhabitants. In Germany there are 3 illiterates to each 1,000 of population, while in England there are 10. The most illiterates are to be found in Russia, where there are 617 to every 1,000 inhabitants. In Germany 68 per cent of the attendance at the schools is composed of children between the ages of 5 and 15; in Russia the average is only 27 per cent.—*The Journal of Industrial Chemistry.*

Optical Phenomena Produced by Pollen.—According to *La Nature*, Prof. E. Daguin of Bayonne, France, has communicated to the French Astronomical Society of France a curious observation, which he made toward 7 o'clock in the evening on May 7th, while traversing by rail a pine forest between Dax and Bayonne. A series of fine coronæ encircled the disk of the sun, which itself was colored deep red. These coronæ resembled those seen on looking at a flame through a glass plate covered with lycopodium powder, an experiment which can be easily performed by the reader. Prof. Daguin supposes that we must attribute to the pollen grains interposed between the sun and the eye the coronæ effect, the pines being in full bloom at the time of the year when this observation was made. The so-called "sulphur rain" which is sometimes observed, is due to the precipitation of such pollen grains. Prof. Daguin remarks that, after the atmosphere had become cleared by such a sulphur rain, the phenomenon of the coronæ was no longer observed.

The Artificial Ripening of Fruit.—For some time past horticulturists have "forced" the growth of flowers and fruits by subjecting the plants to the vapor of ether or chloroform. In this way lilacs for example can be readily obtained in winter. Until the present time, the experiments made in this direction were conducted along more or less empirical lines, the effect was observed without any attempt to produce it in the most rational way. An American agronomist, Mr. Vinson, has taken up the problem scientifically, and has carried on a systematic investigation of the influence of various substances upon the ripening of fruit. He observed that generally the ripening takes place the more rapidly, the more volatile the substance to which the plant is subjected. Heat also powerfully stimulates the ripening process. It appears that the action is due to the fact that the intracellular enzymes, which, as is well known, play an important roll in natural syntheses, are rendered soluble. In practice, in the treatment of dates, the best results are obtained with acetic, propionic, lactic, and salicylic acid. Fruits thus forced to maturity are generally found to keep better than those ripening naturally.—*La Nature.*

TABLE OF CONTENTS

PAGE

I. A Great Oil Well on Fire.—Heroic Measures Adopted to Extinguish the Blaze.—2 illustrations.. 178
II. The Great Star Map.—III.—Counting Stars.—By Prof. H. H. Turner. ... 179
III. Machine Beauty.—Aestetic Evolution in Engineering Structures.—6 illustrations.. 180
IV. Practical Aspects of Printing Telegraphy.—VIII.—By Donald Murray, M.A.—1 illustration 181
V. The Career of the Investigator.—By Prof. W. B. Cannon 182
VI. Mechanical Service for the Furnace in the Modern Industrial Plant.—Conveyors and Chutes for Feeding Coal and Carrying Off the Ashes.—10 illustrations..... 184
VII. The Velocity of Röntgen Rays..... 185
VIII. Simple Experimental Evidence for the Presence of Ions.—By Charles W. D. Parsons 186
IX. The Acme of Refinement in Mechanism.. ... 187
X. New Method for Studying Gastric Secretions.—By Our Paris Correspondent.—2 illustrations... 188
XI. Micrometer for Reading Directly the Various Systems of Measurement.. 188
XII. The Most Remarkable Tree in the Country.—A Fine Example of Giant Vegetable Growth.—2 illustrations. 189
XIII. Some Historic Conflagrations... 189
XIV. Deterioration of Macadam Roads and the Probable Cure.—The Problems that Arise from the Increased Automobile Traffic.—By Samuel D. Foster 190
XV. New Determination of the Moon's Distance.—By A. C. D. Crommelin, D.Sc., B.A. ... 191
XVI. Lathe Bracket for Blue-prints.—By L. H. Georger. 191